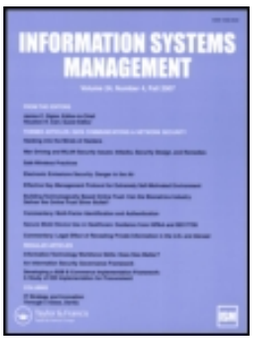

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REAL-TIME BUSINESS INTELLIGENCE: BEST PRACTICES AT CONTINENTAL AIRLINES

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Data management for decision support has moved through three generations, with the latest being real-time data warehousing. This latest generation is significant because of its potential for affecting tactical decision making and business processes. Continental Airlines is a leader in real-time business intelligence, and much can be learned from how they have implemented it.

THE MOVEMENT TO REAL-TIME IS THE latest development in business intelligence (BI) and data warehousing. Real-time data warehousing provides the data that is required to implement real-time BI. By moving to real-time, firms can use BI to affect current decision making and business processes. This capability is especially important for customer-facing applications, such as those found in call centers and check-in processes, and helps firms become more customer-centric. Terms such as "real-time enterprise" and "zero latency organization" are often used to describe firms that use real-time BI.

The purpose of real-time BI is to increase revenues and decrease costs. Companies that successfully implement real-time BI can dramatically improve their profitability. For example, Continental Airlines, which is discussed later, has taken a $30M investment in hardware, software, and personnel to generate more than $500M in revenue enhancements and cost savings, resulting in a return on investment (ROI) of greater than 1,000 percent.

To be successful with real-time BI, organizations must overcome both organizational and technical challenges. On the organizational side, there must be executive sponsorship and support, initial and ongoing financial support, in-place governance processes, BI and data warehousing personnel with the requisite skills, changes in business processes, and acceptance of use of real-time data by organizational personnel. On the technical side, new hardware and software must be acquired and implemented, processes and procedures for supporting and managing real-time data feeds from source systems must be established, data must be quickly transformed and loaded into the warehouse, and the data must be analyzed and made available to operational systems and personnel.

In this article, we provide frameworks and discuss key issues that are helpful in understanding real-time BI. We then use Continental Airlines as a case study of highly successful real-time BI. In 2004, Continental won The Data Warehousing Institute's Best Practices and Leadership Awards. We first briefly discuss Continental and their business strategy that led to implementing real-time BI. Then we describe an application that illustrates Continental's use of real-time BI and focus on some technical and

Real-time data warehousing is the latest of three generations of data management for decision support.

organizational issues associated with Continental's implementation of real-time BI.

PUTTING REAL-TIME BI IN PERSPECTIVE

Before we explore real-time BI at Continental, it is useful to put real-time BI and data warehousing in context. In particular, real-time data warehousing is the latest of three generations of data management for decision support. It is also useful to sort out what real-time really means as it applies to BI. Finally, we discuss latency, its impact on the value of data, and how it requires both technical and organizational solutions.

Three Generations of Data Management in Decision Support

The use of data for decision support can be conceptualized as moving through three generations. The *first generation* emerged with decision support systems (DSS) in the early 1970s. It was recognized that DSS applications required a repository of data, some of which was sourced from operational systems, but also other data, such as external data. The data was customized for the specific DSS that was developed. This was a very application-centric approach, with the data supporting a single or a few related applications. It did, however, show the critical role of data in decision support. In his seminal work on decision support, Sprague (1980) provided the data–dialog–models (DDM) paradigm, which recognizes data as one of the cornerstones of DSS.

The *second generation* emerged in the late 1980s. Firms in the telecommunications, retailing, and financial services industries built data warehouses to store vast amounts of customer and sales-related data. Companies in these industries remain leaders in terms of the size of their warehouses and how the warehouses are used. Unlike DSS in the first generation, data warehouses tend to be data-centric. Although a single or a few applications may be used to help make the business case for the warehouse, the data is modeled to support a variety of applications. The phrase "single version of the truth" is commonly used to describe the official repository of data that applications are supposed to use (Gray and Watson, 1998).

In the year 2000, the movement to real-time data warehousing was the beginning of a *third generation*. The major reason this development is significant and worthy of being called a new generation is the changes in the way warehouse data is used. Previously, the data was employed primarily to understand what had already happened and to predict what would happen in the future. Its use for influencing real-time decisions and current operations was limited. With real-time data, current decisions and critical business processes, such as customer-facing and supply chain applications, can be significantly enhanced.

Real-Time or Right Time?

For many people, "real-time" is synonymous with "instantaneous." This interpretation, however, is incorrect when applied to data warehousing. Although some warehouse data may be captured and entered into the warehouse in seconds or minutes, much of it is not. For example, some source systems, such as a legacy COBOL program that is updated once a month, can never be more real-time than when last updated. Some data may be prohibitively expensive or difficult to make real-time. Most important, there may not be a business need for real-time data. Data only needs to be as fresh as the business requirements. For these reasons, some people prefer the term "right time" (White, 2004). We use the terms simultaneously and recognize that real-time does not always mean instantaneous.

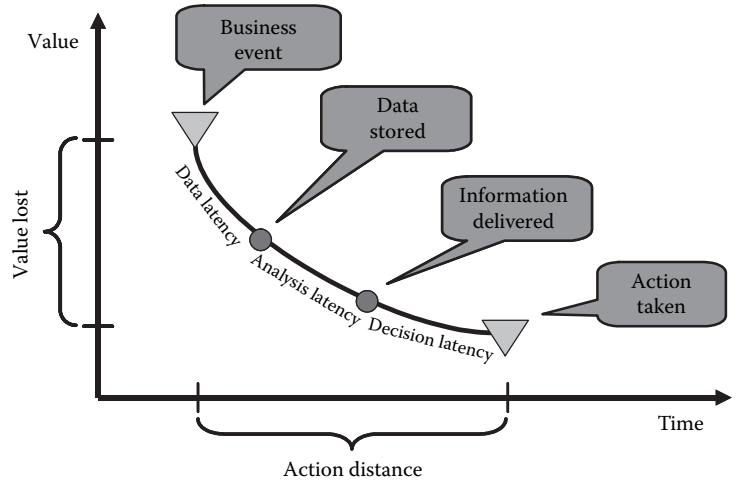
The Latency and Value of Data

In most cases, the value of data decreases rapidly as it ages. Stated differently, low-latency (i.e., fresh) data has more value than high-latency data. This is why the movement to real-time BI is appealing.

Richard Hackathorn provides a useful perspective on latency as applied to data warehousing (Hackathorn, 2004). He identifies three kinds of latency (see Figure 1). *Data latency* is the length of time between when an event occurs and when the associated data is stored in the data warehouse. *Analysis latency* is the time between when the data is stored and when it is analyzed and made available to applications and users. *Decision latency* is the time from when the information is available until some action is taken on it. These three sources of latency are additive and result in total latency.

Reducing data and analysis latency depends primarily on technical solutions. Recent developments in real-time data warehousing help in this regard. However, reducing decision latency requires changes in business processes and how people use information in performing

FIGURE 1 Three Types of Latency (based on Hackathorn, 2004)



their jobs. Providing fresher data does not create business value unless it is used in a timely manner. Dealing with decision latency is usually more challenging than data and analysis latency.

CONTINENTAL AIRLINES: A CASE STUDY

Continental Airlines is a leader in real-time BI. It has received numerous awards for its work, including The Data Warehousing Institute's Best Practices and Leadership Award in 2004. Continental's experiences with real-time BI illustrate the challenges, solutions, and business value associated with real-time BI.

About Continental Airlines

Continental Airlines was founded in 1934 with a single-engine Lockheed aircraft in the American Southwest. Over the years, Continental has grown and successfully weathered the storms associated with the highly volatile, competitive airline industry. With headquarters in Houston, Texas, Continental is currently the United States' fifth largest airline and the seventh largest in the world. It carries approximately 50 million passengers a year to five continents (North and South America, Europe, Asia, and Australia), with more than 2,300 daily departures to more than 227 destinations. Continental, along with Continental Express and Continental Connection, now serves more destinations than any other airline in the world.

Continental's Business Strategy

Continental was experiencing major business problems in the early 1990s when Gordon Bethune became CEO. At that time there were ten major U.S. airlines, and Continental consistently ranked tenth in the Department of Transportation metrics used to monitor the industry's performance: on-time arrivals, baggage handling, customer complaints, and denied boardings because of overbooking. Not surprising, with this kind of service, Continental was in financial trouble.

CEO Bethune and Greg Brenneman, who was a Continental consultant at the time, conceived of and sold to the Board of Directors the Go Forward Plan, which had four interrelated parts that had to be executed simultaneously:

Fly to Win. Continental needed to better understand what products customers wanted and were willing to pay for.

Fund the Future. It needed to change its costs and cash flow so that the airline could continue to operate.

Make Reliability a Reality. It had to be an airline that got its customers to their destinations safely, on time, and with their luggage.

Working Together. Continental needed to create a culture where people wanted to come to work.

Under Bethune's leadership, the Go Forward Plan, along with a reenergized workforce, helped Continental make rapid improvements. Within two years, it moved from "worst to first" in many airline performance metrics, including on-time performance, lost baggage claims, and customer satisfaction.

After this success, Gordon Bethune and his management team raised the bar with a new vision. Instead of merely performing best, they wanted Continental to be their customers' favorite airline. The First to Favorite strategy built on Continental's operational success and focused on treating customers extremely well, especially high-value customers.

The Role of Information Technology

The movement from "worst to first" was only partially supported by information technology. Historically, Continental had outsourced its operational systems to EDS. These included mainframe systems that provided a limited set of scheduled reports and no support for ad hoc queries. The airline lacked the corporate data infrastructure that a broad range of employees

Fortunately, the warehouse team had anticipated and prepared for the ultimate move to real-time.

could use for quick access to key insights about the business.

In 1998, the decision was made to develop an enterprise data warehouse through which all employees could gain quick access to important information about the business and its customers. The CIO at the time, Janet Wejman, recognized that the warehouse was a strategic project and she brought the development and the subsequent maintenance and support in house. She believed that the warehouse was core to Continental's business strategy and should not be outsourced.

The data warehouse provided a variety of early, big "wins" for the business. The initial applications for pricing and revenue management were followed by the integration of customer information, finance, flight information, and security. They created significant financial lift in all areas of the Go Forward Plan.

However, when Continental moved ahead with the First to Favorite strategy, it became increasingly important for the warehouse to provide real-time, actionable information to support tactical decision making and business processes. Fortunately, the warehouse team had anticipated and prepared for the ultimate move to real-time. Real-time meant that the warehouse team had to introduce real-time feeds of data into the warehouse, extract data that the warehouse produced and incorporate it back into legacy systems, and open the warehouse to tactical queries with sub-second response time requirements. In preparation, the team had developed a warehouse architecture that could grow and scale to meet these new real-time and operational needs. Although not all applications required real-time data, many did. In 2001, real-time data became available in the warehouse.

Real-Time BI Applications at Continental

Continental's real-time applications fall into the following five categories:

- Revenue management and accounting
- Customer relationship management
- Crew operations and payroll
- Security and fraud
- Flight operations

The objective of revenue management is to maximize revenue given a finite set of resources. An airline seat is a perishable good; an unfilled seat has no value once a plane takes off. The revenue accounting area seeks to quickly and accurately record the revenues Continental generates, including estimating the revenues from any flight soon after "the wheels are up."

The marketing group employs customer relationship management (CRM); this increases revenues and profits and improves customer service because it allows Continental to know its customers exceptionally well (e.g., customer value and flying preferences) and give them great service. Continental's marketing group uses the warehouse for customer segmentation and target marketing, loyalty/retention management, customer acquisition, channel optimization, and campaign management.

The crew operations group is concerned with issues related to pilots and flight attendants. It is involved in crew pay, crew scheduling, crew performance, and crew efficiency. The data warehouse is used in conjunction with all of these activities at varying levels.

Continental also uses its warehouse to identify reservations that are not in fare and contract compliance and to profile suspicious booking and ticketing transactions. It is also used to support airline security efforts.

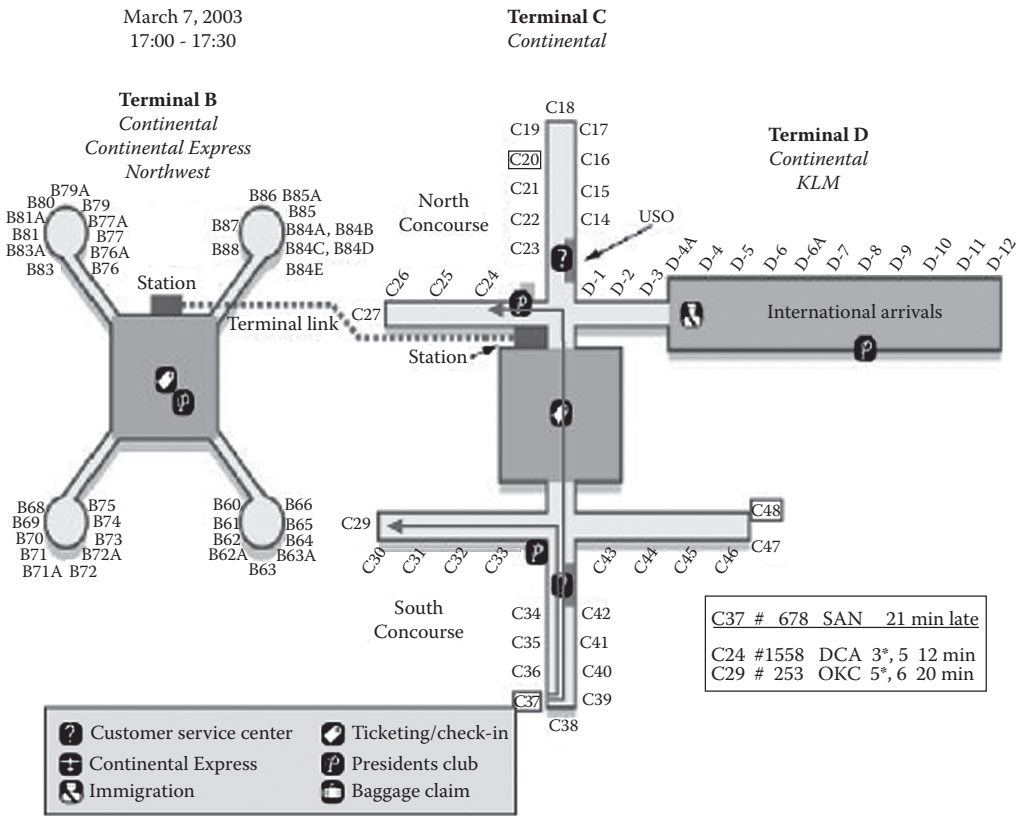
Real-time applications have also been developed for flight operations. The objective is to get people to their destinations safely, on time, efficiently, and with their luggage. This is where customers have either a good or bad flying experience, and Continental works hard to provide consistently excellent service. One of the flight operations applications is the Flight Management Dashboard; it is described in depth here as an example of how Continental uses real-time BI.

Flight Management Dashboard

The Flight Management Dashboard is a set of interactive graphical displays developed by the data warehouse group, with input from the operations staff at Continental's hub in Newark, New Jersey. These displays are intended to help the operations staff quickly identify issues in the Continental flight network and then manage flights in ways that improve customer satisfaction and airline profitability.

Some of the dashboard's displays help the operations staff better serve Continental's high-value customers. For example, one of the displays is a graphical depiction of a concourse, which is used to assess where Continental's high-value customers are or soon will be in a particular airport hub (see Figure 2). The display indicates the gates where these customers have potential gate connection problems so

FIGURE 2 Concourse Display of High-Value Customer Activity



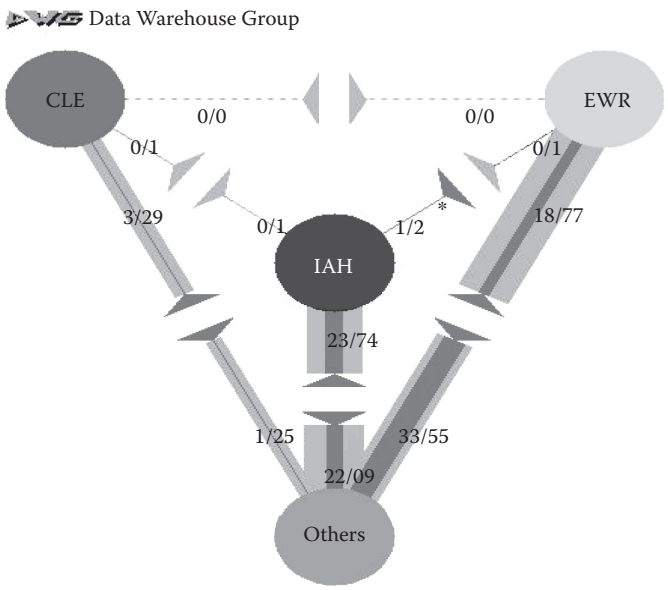
that gate agents, baggage supervisors, and other operations managers can assess where ground transportation assistance and other services are needed so that these customers and their luggage avoid missing flights. For example, in Figure 2, it can be seen that Flight 678 is arriving 21 minutes late to Gate C37 (see the box in lower right-hand side). Three high-value customers will need assistance in making their connections at Gate C24, and they will have only 12 minutes to make the flight. Five high-value customers need to get to Gate C29 and will have only 20 minutes to do so.

On-time arrival is an important operational measurement at Continental. Therefore, another critical set of dashboard displays helps operations keep the flight arrivals and departures on time. One display shows the traffic volume between the three Continental hub stations and the rest of their network (see Figure 3). The line thickness between nodes is used to indicate relative flight volumes and the number of late flights so that the operations staff can anticipate where services need to be expedited. The ratio of the number of late flights to the total number of flights between the hubs is also shown. The operations staff can click on the lines and drill down to see individual flight information. Another line graph summarizes flight lateness. Users can drill down to more detailed pie charts that show degrees of lateness, and then, within each pie, to the individual flights in that category. Another chart concentrates on flights between the United States and Europe and the Caribbean and can show similar critical flight statistics. For all of these dashboard elements, high-level views can be broken down to show the details on customers or flights that compose different statistics or categories.

The Architecture for Real-Time Business Intelligence

The architecture underlying the Flight Management Dashboard is not trivial and is built on a real-time data warehousing foundation. At the core is an 8-terabyte enterprise data warehouse running on a 3-GHz, 10-node Teradata 5380 machine. The warehouse supports 1,292

FIGURE 3 Display of Flight Lateness From/To Hubs



*Number of flights due to arrive late

users across Continental who access 42 subject areas, 35 data marts, and 29 applications. Sixteen of these users are "power users" of the Flight Management Dashboard; other users access the dashboard infrequently for special decision support needs.

The basic architecture of the warehouse is shown in Figure 4. Data from 25 internal operational systems (e.g., the reservations system) and two external data sources (e.g., standard airport codes) is loaded into the warehouse. Some data (e.g., customer value analysis) is fed from the warehouse back into the operational systems. All of the data are stored at the lowest level of detail in the Teradata database.

Real-Time Data Sources

To deliver the Flight Management Dashboard application with the functionality described earlier, the warehouse team needs data about a flight's current status combined with passenger information. This requires two primary real-time data sources: (1) the satellite feeds that are transmitted from airplanes and (2) the central customer database. Because these data sources exist in two very different technical environments, they must be extracted from the sources in different ways.

The flight data (called FSIR, or flight system information record) is sent real-time from the airplanes via satellite to an operations control center system, which supports the command center for Continental where the actual flights are coordinated. The data warehouse team took advantage of the command center infrastructure already in place, setting up a Windows NT machine that "listens" to the FSIR data and feeds the appropriate data (as they occur real-time) into a warehouse queue.

Whereas the warehouse team uses a "pull" process for flight data, a "push" process is used for the passenger data. The passenger data sits in a central Oracle customer database that is accessed and updated by Continental's reservations system, the One Pass frequent flier program, the Web site (www.continental.com), and customer service applications. Every time a change is made to a customer record in the customer database, an Oracle trigger is activated, which sends the update as XML-encoded data to a queue for loading into the warehouse.

Although these two data sources have clear technical differences and need different extraction processes, Continental created an infrastructure called the Service Bureau that allows the various sources to be captured and monitored using a single, reusable infrastructure and then loaded in a uniform way. The data capture, monitoring, and loading processes are described in the next two sections.

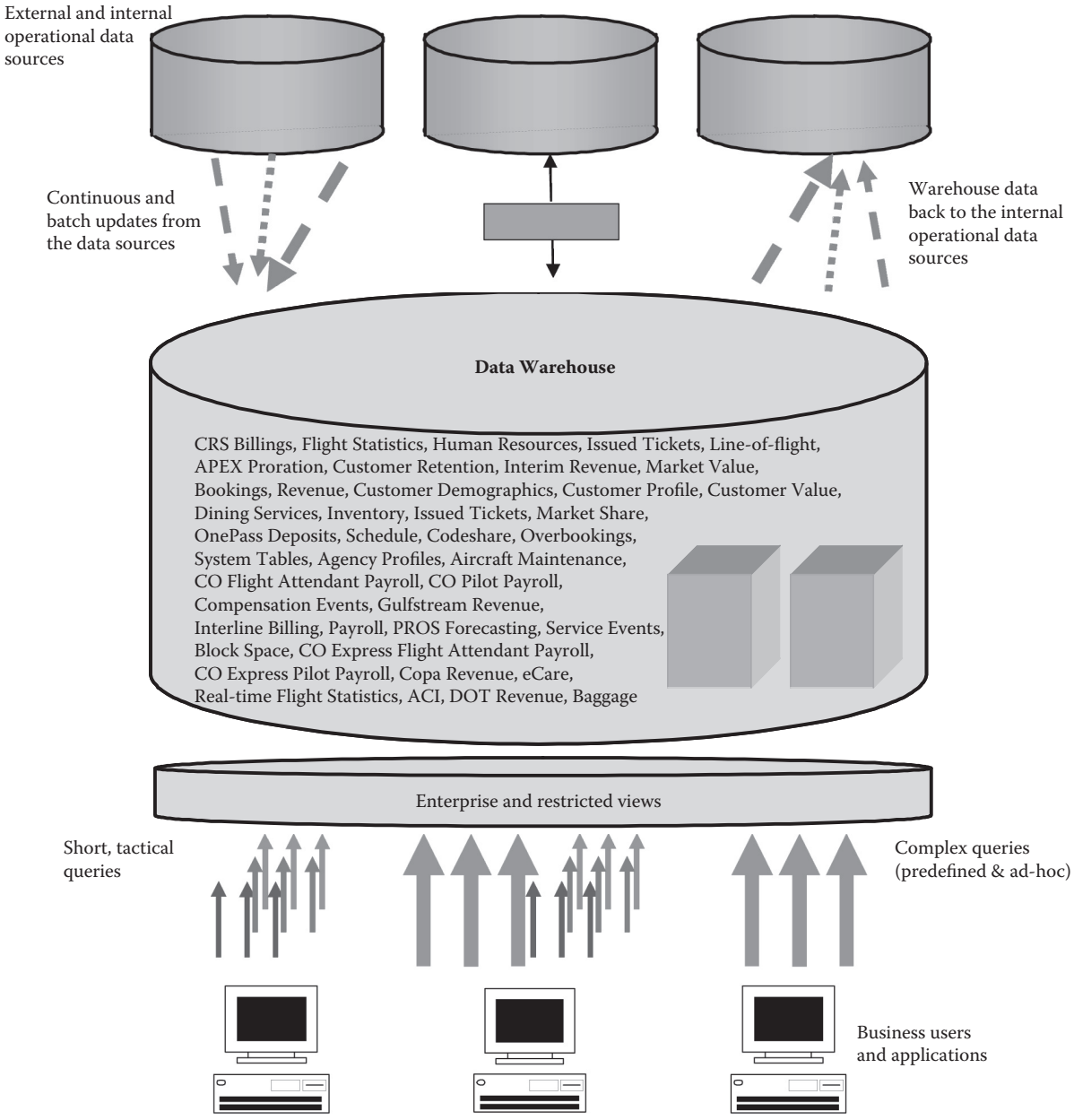
Data Capture and Monitoring

Continental's vision from the start was for the data warehouse to be highly automated. To achieve this, the warehouse team built a set of shared services that run on ten Windows-based servers called the Continental Service Bureau. The Service Bureau was built using object-oriented design techniques, and it automatically loads and manages the warehouse. Its object orientation facilitates efficient, parallel, scalable, and restartable transformation processes. The Service Bureau contains a number of components, which are listed in Figure 5.

The Service Bureau's scheduler has about 50 tasks that run at specific time intervals (from minutes to hours) and other tasks that run at specified times. Many of these tasks first check whether a load is ready to run and, if so, start it. Most of the loads depend on either a file becoming available through the Internet or the completion of another load. The dependencies are quite complex.

The Service Bureau manages a series of automated alerts that page the on-call warehouse staff member when some process needs

FIGURE 4 Data Warehouse Architecture



human intervention. If the on-call person fails to respond and fix the problem, a page is sent to a secondary support person.

The Service Bureau monitors the number of items in the various work queues for the real-time loads, and if the queues fill up beyond certain preset thresholds, it issues an alert, paging the on-call staff. The Service Bureau also notifies the on-call staff member when any data warehouse load fails, or a data feed is not available in time, or a batch load process is taking too long and is projected to finish beyond its allotted time. It also monitors the latency of the data in the warehouse and issues an alert if it gets beyond a predefined value.

For batch loads, the Service Bureau notifies the users of the data when their data has been loaded and is ready for access.

A Standard Data Loading Process

More than half of the daily data added to the warehouse is loaded throughout the day, with varying degrees of latency. This includes the

FIGURE 5 Components of the Service Bureau

- A set of components and libraries that implement the common services, scheduler, file transfer, and data conversion programs
- A watchdog service to ensure other services are up
- A system for paging on-call personnel through the Skytel service
- An e-mail queuing service that connects to the corporate e-mail system
- Microsoft Component Object Model (COM) components that provide a uniform Data Access Layer for Web and other clients for logging and connection pooling to minimize database connection usage
- A set of services that transform and load reservations and operational data into the warehouse in real-time
- A process that monitors the performance of the data warehouse, keeps history, and alerts the warehouse staff to exceptionally long-running queries
- Automatically generated meta data that is refreshed and published on the Intranet
- An SQL Server operational database that stores configuration and status data, control of Teradata load utilities, and monitoring of MVS jobs through 3270 emulators
- Real-time display of what each service is doing in each transformation server machine

flight and passenger data required for the Flight Management Dashboard application.

Within the Service Bureau, data feeds are treated similarly regardless of their source. As feeds evolve from batch to real-time, there are minimal changes to the loading process. Regardless of latency, data feeds are transformed and sent to queues, which then are loaded using the real-time loading utility provided by Teradata. Figure 6 provides an overview of the data loading process.

Because the standard loading process is generic and reusable, as users demand more and more real-time data, and as real-time feeds become available, incorporating real-time data into the warehouse is relatively simple.

Managing Mixed Queries

Traditional warehouses are optimized to support strategic queries that require many table joins and aggregations. However, this is not the case with queries associated with real-time BI. For example, as the operations staff accesses the Flight Management Dashboard application, they need to know a specific flight's status at a certain point in time (usually the current time), and they expect an immediate response to their query. This type of query is tactical and, therefore, requires a different query response strategy than a strategic query to ensure appropriate performance.

The challenge is to optimize real-time warehouses so that strategic and tactical queries can coexist. Users of the Flight Management Dashboard application need to "hit" the same data as users of more strategic applications without degrading overall performance of the warehouse. Continental's optimization strategy aligns with its overall vision to "keep things simple," and this approach has worked well.

The warehouse team takes advantage of the data warehouse's existing priority scheduler application to help manage the mixed query loads. Concrete rules determine the priority settings for users and applications. The tactical queries that access single records are set to *high* priority. These queries usually come from applications, such as the Flight Management Dashboard, that require instantaneous response time. Daytime data loads are set to

FIGURE 6 Real-Time Data Loading Process

- Continuous data loads use software, such as CDC (Change Data Capture), or special hooks or triggers on the operational systems to capture events of interest
- Special queue middleware, such as MQ series, Oracle AQ, and MSMQ, move the data to dedicated transformation servers
- Each update to the operational systems "triggers" a record to the queue
- Service processes continuously monitor these queues and transform each piece of data that gets loaded into the warehouse using the Teradata continuous load TPump facility
- Strategic and tactical queries can run the same time that data is being loaded

- In the case of batch updates, the operational systems create nightly files that are FTP'd to the transformation servers where they create an event that causes the transformation programs to run. These programs transform the data and push the transformed data through the Teradata Fastload and Multiload utilities to load the data into the warehouse

low priority. And users who perform ad hoc queries are given *medium* priority access.

The Service Bureau continuously monitors all of the queries to identify those that are using too much of the system's resources. For example, when queries run longer than one hour, the monitor service alerts someone on the data warehouse team. Query responses that are not needed immediately are set to the lowest priority. Warehouse team members work with users to help them understand how to optimize inefficient queries.

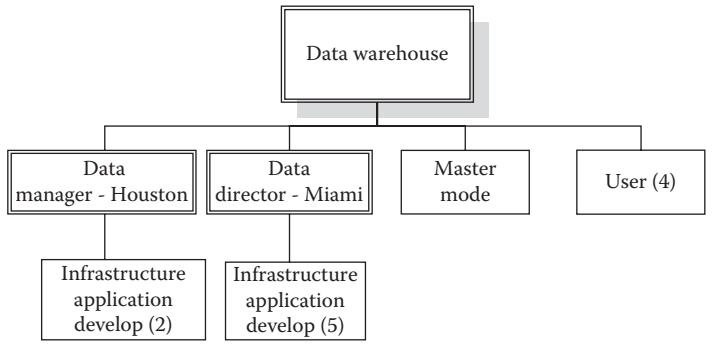
THE DATA WAREHOUSE TEAM

Continental's data warehouse team consists of 15 people. They are responsible for managing the warehouse; developing and maintaining the infrastructure; modeling data; developing and maintaining extraction, transformation, and loading (ETL) processes; and working with the business units. The organization chart for the data warehouse staff is shown in Figure 7.

The data warehouse director reports to the chief information officer. The warehouse staff is located at the Houston headquarters and in Miami. When the warehouse initiative began, Continental filled the director position with a highly experienced manager based in Miami who had previously worked with data warehouse professionals who were available for hire if they could continue to live in Miami. The Houston and Miami groups work as a team and share the infrastructure development and maintenance work, including building the processes that source data for the warehouse. The most technical people on the team have degrees in computer science. Everyone on the data warehouse team wears many hats, including providing operational support for the warehouse. However, they also have specialized roles. For example, the master data modeler has ultimate control over the warehouse's enterprise data model.

Four team members have specific support roles. Three work with the revenue management, marketing, and crew operations areas; the fourth is responsible for supporting end-user BI software and miscellaneous tasks. All of the support people originally worked in the user areas they now support and, therefore, are experts on the data for those areas. They assist rather than build applications for the business areas. Several team members have extensive work experience with operational systems,

FIGURE 7 Data Warehouse Organization Chart



which has helped them in implementing real-time data warehousing.

IMPLEMENTING REAL-TIME BUSINESS INTELLIGENCE

Over time, business needs will drive other organizations to evolve into the third generation of decision support data management. There are several nuances to real-time BI that organizations need to consider, and below we provide some guidelines for them.

Changes in latency may require an evolution. Business needs increasingly require more real-time data; however, reducing the three kinds of latency in Figure 1 requires technical solutions, a strong business case, and process change. Putting these three factors in place may take time and may also require an evolutionary approach in which organizations move to real-time data in incremental steps. A key to success is for the organization to recognize that latency needs will change and then to construct an architecture that can handle the eventual movement to real-time.

Continental recognized the need and planned for real-time BI at the outset of its data warehousing initiative. For example, the Service Bureau infrastructure supports data loads using queues, and this approach works for both batch loading and real-time feeds. The Service Bureau is set up to continuously monitor all warehouse processes and respond rapidly to issues (e.g., data loading failures, long query response times); it automates all processes all the time, regardless of how often they run. This situation has helped Continental transition painlessly to real-time BI.

It is important to define what real-time means to your organization. A flight is considered "late" within the airline industry if it takes off or arrives more than 14 minutes after its scheduled time. When the data warehouse director discussed "real-time" with the business, she used 14 minutes as her latency window because that number made sense from a business perspective.

Specifically, the Flight Management Dashboard relies on satellite data that is captured and loaded into the data warehouse every couple of seconds. With service levels of 14 minutes or (typically) less, the operations users can feel confident in the data as they make real-time decisions that affect current flight operations.

Users need help initially understanding the potential of real-time BI. At first, the operations staff did not understand why they would need a BI application to help manage their day-to-day tasks. The data warehouse team had to first present some ideas to the users to stimulate dialog and excitement. The data warehousing staff began by creating the concourse map screen, which is a key piece of the Flight Management Dashboard application. When users saw how data could be depicted graphically (e.g., as an actual concourse with colors and lines that have special meaning), they came up with their own ideas for how real-time data could help them operate the hubs better. Once users appreciate what is possible, they are more likely to say, "Help me change the way we do business." At Continental, the current challenge is to find the time to support the ideas users have.

Real-time BI requires the automation of ETL processes. Feeding real-time data to a data warehouse is analogous to running a manufacturing plant. The processes should be as automated as possible. There should be minimal human intervention unless monitoring systems detect a condition that requires attention. Furthermore, the processes should be flexible and reusable so that changes can be made easily. Continental's vision from the start was for the warehouse to be self-maintaining. The warehouse team developed automated processes (in the Service Bureau) that minimize human intervention and can be used across source systems and with new source systems that come online.

The successful coexistence of strategic and tactical decision support requires business and technical solutions.

Strategic and tactical queries must be carefully managed to successfully coexist. Historically, data warehouses have focused on providing strategic decision support. With the emergence of real-time data warehouse technologies, decision support has expanded to the tactical level, as well as supporting strategic decision making.

Strategic and tactical decision support systems have different characteristics. Strategic decision support typically involves the analysis of large amounts of data that must be "sliced and diced" in various ways. Tactical decision support often requires repeatedly accessing only a limited amount of data. The performance requirements (i.e., response time) are greater for tactical than strategic decision support, because there is a smaller window of time for when the information is useful. The resource demands for strategic decision support are often greater and more varied than for tactical decision support (e.g., data mining versus accessing a customer value score).

The successful coexistence of strategic and tactical decision support requires business and technical solutions. On the business side, priorities must be set for the processing of queries from users and applications. For example, a data-mining query should have a lower priority than a tactical query. There must be capacity planning for each class of query. On the technical side, there must be a query manager that recognizes the priorities of the queries, monitors queries, defers long-running queries for later execution, and dynamically allocates query resources.

Real-time BI blurs the line between decision support and operational systems. In many companies, the operational and decision support systems are "islands." Each has its own staff, processes, and standards. The only significant point of interaction is the extraction of data from operational systems. And the systems are managed in different ways. Operational systems have more stringent service-level requirements and more sophisticated business continuity processes in place.

The Flight Management Dashboard is one example of the blurring of the distinction between decision support and operational systems. As the operations staff relies more on the application to manage and make operations decisions, the application will become more "mission critical." Continental will have to ensure that the application is treated in an operational way; otherwise, business processes will break down.

Focus on changing downstream decision-making and business processes that are enabled by real-time BI. When the Flight Management Dashboard was first proposed, the person responsible for creating the overnight performance reports was not convinced that real-time information was needed. It was only after this person had worked with the real-time data for a while that he recognized its value and integrated it into his work. Now he is actively developing an application that will present real-time information in an even better way.

Clearly, when organizations delve into the real-time BI world, they need to apply change management practices and work with decision makers to ensure that benefits of real-time BI are realized.

CONCLUSION

As some organizations identify the need to move to the third generation of decision support, they may see the migration as "crossing a chasm" because of the dramatic changes to technology architecture and organizational processes that will need to occur. Those organizations that recognize the progression of decision support early on, may instead be able to lay groundwork to facilitate a more comfortable transition to real-time BI over time.

As we see with Continental, clear technical, business, and process changes must be put in place to enable real-time BI. The Continental case offers an approach for moving to the third generation of decision support from which other organizations can learn.

First, find a clear business need for decisions that require real-time data. At Continental, the operations staff could directly impact costs and revenues by altering gates, rerouting baggage, and making other operating modifications — but only if the data reflected the business at the current time. It was obvious that only real-time BI would be able to enable decision making for the operations staff.

Next, invest in an architecture that can scale, and then automate as much of the environment as possible. Continental benefited from a mature data warehouse that had been architected to receive data feeds from a system of queues. They also created the Service Bureau to manage and monitor the technical processes automatically. This foundation did not need to change as the latency of data feeds moved from batch to real-time.

Finally, perform a value assessment to support the investment in real-time BI. Continental regularly assesses how applications are impacting the company's bottom line. It does not plan to feed all data warehouse applications with real-time data, because the cost and effort are prohibitive for some applications when compared to the benefits. Applications that can leverage real-time BI by impacting business processes to create value to an organization will represent the third generation of decision support.

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Notes

Additional information about the real-time BI best practices at Continental is presented in R. Anderson-Lehman, H.J. Watson, B.H. Wixom, and J.A. Hoffer, "Continental Airlines Flies High with Real-Time Business Intelligence," *MIS Quarterly Executive*, 3:4 (December 2004), 163–176. The story of Continental's turnaround can be found in G. Brenneman, "Right Away and All at Once: How We Saved Continental," *Harvard Business Review*, 76:5 (September/October 1998), 162–74. ▲

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