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Metadata Management: the Foundation for Enterprise Information Integration

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Metadata Management: the Foundation for Enterprise Information Integration

Thiru Thangarathinam, Information Services and Technology Group, Intel Corporation
Gregg Wyant, Information Services and Technology Group, Intel Corporation
Jacque Gibson, Information Services and Technology Group, Intel Corporation
John Simpson, Information Services and Technology Group, Intel Corporation

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ABSTRACT

Metadata Management helps you understand what information you have, where it is located, and what value it provides to users. Users can view information in a context they understand, providing a more efficient and intuitive way to communicate. To achieve this kind of enterprise-wide information integration, companies need to describe and share, in a common way, the data in their disparate data sources. This should include the business description associated with the information asset, as well as location, connection details, data type details, and the information's relationship with other resources. Sharing this information leads to an increased visibility of information across an enterprise, shorter development times, and reduced operational costs as the organization can discover and eliminate redundant information sources.

In this paper, we explore how Metadata Management streamlines the application development process by reducing the development, deployment, and maintenance costs. This is made possible by the use of a single source of Metadata for logical, physical, and process aspects of the application environment, when tracking versions of the code and documenting all aspects of the application development life cycle. By providing a complete, integrated view of the development environment, Metadata helps identify redundant processes and applications, thereby reducing duplicated efforts. (For the purposes of this discussion, we are treating "Metadata" as a singular noun.) Developers can share and reuse existing objects such as data structures, programs, model definitions, and more. In addition, enterprise impact analysis greatly reduces the analysis and maintenance phase of the development life cycle.

INTRODUCTION

Have you ever wondered about the definition of a piece of data? Has something stopped working and you don't know why? Do you need to make a change in the environment and want to know ahead of time what will be impacted by your change? The answers to all of these questions can be found in Metadata. Metadata is information about data. It answers the who, what, when, where, why, and how of every piece of data being documented throughout the enterprise and is the enabler for reuse. Historically, Metadata has been defined as "data about data." Metadata can also be thought of as the "DNA" of your corporation. Through its systematic capture during the creation of the assets in your enterprise architecture, you can search, catalog, and ultimately reuse corporate assets, achieving enterprise-wide information integration.

To achieve this enterprise-wide information integration, companies need to describe and share, in a common way, the data in their different data sources. This should include the business description associated with the information asset, as well as its location, connection details, data type details, and the information's relationship with other resources. Sharing this information leads to an increased visibility across an enterprise, shorter development times, reduced operational costs as redundant information sources are identified and eliminated, and improved data quality as organizations begin to reuse approved information. The best way to manage and share this information is through a centralized Enterprise Repository that drives the connections between data, process, and applications, enforces standards, and is available to all employees.

As the number of applications in an organization increases and the time to design these applications decreases,

companies begin to recognize the need for a Metadata Repository. However, all too often they focus primarily on implementing a tool and neglect the Metadata Management aspect. This results in a Repository that is easily accessible, but not often used because the information lacks credibility. To be of value to the enterprise, Metadata must be managed using repeatable processes to identify and define the Metadata, standard deliverables to capture the Metadata, and approved governance processes to ensure ongoing Metadata credibility. This management allows users to understand what information they have, where it is located, and what value it provides. Plus, users can view information in a context they understand.

METADATA REPOSITORY ARCHITECTURE

As an enterprise infrastructure component, a Metadata Repository should provide a single, secure, and standard method for providing Metadata to end users. One of the key components of a Metadata Repository is its data collection architecture. There are three types of data collection architectures that can be employed. They are as follows:

- *Distributed Data Collection Architecture*. In this architecture, also known as the Active Repository, the Metadata Repository maintains pointers to external Metadata sources rather than creating and maintaining duplicate copies, thus eliminating all synchronization issues.
- *Centralized Data Collection Architecture*. In the centralized data collection architecture (known as the Static Repository), the Metadata is copied from various sources to the centralized repository. In a centralized Repository, accessing of the Metadata is independent of access to the original system, as the duplication of the data in the repository frees the system from any required access to the original Metadata.
- *Hybrid Data Collection Architecture*. This method utilizes both distributed and centralized data collection methods in a single repository. A hybrid approach consisting of both distributed and centralized approaches leverages the strengths and mitigates the weaknesses of both distributed and centralized architectures. The hybrid approach facilitates Metadata access in real time from third-party sources and provides the ability to capture additional Metadata attributes not existing in the source repositories. It also lets users create original data within the repository.

The Metadata Repository should also be designed in such a way that it can be fully scaled and customized, thereby enabling it to store a limitless amount of information for any particular object. This flexibility provides the Metadata Repository with the ability to conform to current and future standard initiatives, such as the Common Warehouse Metamodel (CWM) guaranteeing that users of the Metadata Repository will be able to conform to such initiatives as they receive wider adoption. To help enterprises increase information visibility and sharing, a Metadata Management solution should at least contain the following:

- A secure Web-based portal solution to search and analyze Metadata.
- A Metadata Management Engine that provides the standard processes for ensuring the credibility of the Metadata.
- Standards-based Metadata Repository and Metadata Representation. The common Metadata standards it should support are as follows:
  - Meta-Object Facility (MOF)
  - Common Warehouse Metamodel (CWM)
  - Unified Modeling Language (UML)
  - XML Metadata Interchange (XMI)

The following sections discuss each of these components in detail.

Secure Web Portal

The secure Web portal provides a graphically driven, browser-based interface for displaying the information stored in the Metadata Repository. Any authorized user with a secure Internet connection and a browser-enabled computer can have access to the Web portal. The Metadata Repository should also utilize a variety of security measures ensuring that databases and repositories remain secure while at the same time restricting access and usage privileges to only those users authorized by the Metadata Repository system administrator. By providing inherent security features, only those authorized to view appropriate information can view it. This enables business users to view information about the reports they run without confusing them with information about their other processes.

Metadata Management Engine

The Metadata Management Engine provides the core foundation for ensuring the credibility of the Metadata and it consists of the following components:

- *Archiving/Versioning Component*. This component tracks changes to the Metadata for all objects within the Metadata Repository. Through this function, users can monitor specific changes, restore Metadata records for specific objects to previous instances, purge changes from Metadata records, or create reports detailing the audit trail of all changes made for a Metadata record (such as date, time, user, and the nature of a change).
- *Repository Component*. This component is the database repository for storing all the Metadata objects, all of their relationships, and the properties associated with them. For the repository to be extensible and flexible, the Repository Component needs to be built on top of the Enterprise Metadata Model. The Enterprise Metadata Model not only defines all the data structures existing in the enterprise, but also how those data structures will interact within the application integration solution domain. The Repository Component also contains various internal functional subcomponents for governance, development lifecycle integration, configuration, security, and metrics.
- *Scanner Component*. This component is responsible for capturing Metadata from disparate Metadata sources and loading them into the Metadata Repository. Once the Metadata is loaded, it can then be accessed through the secure Web portal. By leveraging the industry-standard XMI specification for capturing Metadata, the Metadata Repository can exchange Metadata models with common modeling tools as well as import Metadata from databases into the Metadata Repository.
- *Administration Component*. This component contains the processes that perform operations such as monitoring quality, change management, classification, configuration, and access management. It also contains Metadata Management processes that are responsible for handling check-in, check-out, and for auditing scanned input to control changes and so on.

Support for Industry Standards

In this next section, we provide an overview of each of the standards and the support a Metadata Repository implementation should provide for each of these standards.

- *Meta-Object Facility (MOF).* The MOF standard defines an extensible framework for defining models for Metadata, and for providing tools with programmatic interfaces to store and access Metadata in a repository.
- *Common Warehouse Metamodel (CWM).* The CWM standard specifies interfaces that can be used to enable easy interchange of warehouse and business intelligence Metadata between warehouse tools, warehouse platforms, and warehouse Metadata Repositories in distributed heterogeneous environments.
- *Unified Modeling Language (UML).* The UML standard provides a graphical language for visualizing, specifying, constructing, and documenting the artifacts of distributed object systems. It also incorporates Action Semantics, which adds to UML the syntax and semantics of executable actions and procedures, including their run-time semantics.
- *XML Metadata Interchange (XMI).* The XMI standard specifies an open-interchange model intended to give developers working with object and distributed technology the ability to exchange data between tools, applications, repositories, business objects, and programs. This is a Stream-based Model Interchange Format (SMIF) that enables the exchange of modeling, repository, and programming data over the network and Internet in a standardized way. XMI is a very important specification that brings consistency and compatibility to applications created in collaborative environments.

Metadata Repository Usage Scenarios

In this section, we demonstrate the different usage scenarios of the Metadata Repository in terms of the roles of the users.

Types of Usage

Impact Analysis

Impact Analysis is a complex discovery of data dependencies in order to realize relationships and uncover exactly how changes to any data elements can cause a cascading effect throughout the relationships. Having a detailed understanding of data as they cut across many functional areas (finance, manufacturing, sales, and others) as well as usage methods (development, process, and workflow) has created new opportunities for leveraging the information we already have to allow for more detailed data-supported decision making.

Metadata Reuse

Metadata reuse is the ability to reuse objects (artifacts) with little or no interruption to the business process. This can be referencing an existing object and creating a relationship to it or using an object as a base to create a new (similar) version. Reuse is where we gain extreme savings in time and resources (people, systems, and data).

Reporting
Reporting is simply data in a summary or detailed view. Examples include understanding all the data elements within a specific table, or knowing how many databases on the physical layer map to a specific contextual entity.

Usage Scenarios

Since customers often approach the repository with problems needing solutions, we present usage scenarios of problems followed by solutions that can be found within the repository.

Data Analyst/Modeler
Impact Analysis. Customer identification numbers need to become longer. Since your data are pushed downstream into the data warehouse, you are unsure of all the systems that could be impacted by this change. These relationships would have been previously discovered in the Metadata Repository, which would help identify your data reuse and the impact of any changes.

Metadata Reuse. You have been given the task of creating the logical model for an upcoming business solution. Through discovery (search and browse in the Metadata Repository), you have found out that there are already the required entities in place to describe the data required. Utilizing the built-in check-out and reservation methods in the Metadata Repository, you can capture reuse associated with the existing entities. During subsequent modeling, you can also map the relationship between these entities and your logical model, thus increasing the usefulness of future data to other users.

Reporting. Data quality efforts are on the rise in your organization, and you are curious whether or not all of your data tables have the column descriptors per the new standard. Through reporting you can identify descriptions that are missing, items that are described incorrectly, as well as potential other problems you should address in the event of more strict requirements around quality. Summary analysis (on screen or in an extract) aid in speedy comparison and identification for future repair.

Applications Developer/Programmer
Impact Analysis. The current project requirement requires the removal of local data stores of user information and reuse of data stored within the Record of Origin (ROO) for customer first and last name. Quick analysis of your operational and physical data implementations show that your data do not leave your system. Without the tools at your disposal to uncover this basic truth, a lengthy discovery process must occur to ensure that all interfaced systems as well as downstream consumers for reporting are not impacted by your changes.

Metadata Reuse. In the example above, you have been given the task of removing a local data store of customer first and last name. In place of the local store, you are going to utilize the consumption of a Web service related to customer information, real-time, and display the subsequent results on screen. Through a search discovery process, you identify the associated Web service and methods necessary to obtain this source of data. Integration into your application is simplified through this process, and an increased level of reuse is realized in the enterprise. Additionally, through a registration process, you are now associated with this external system. This minimizes any future changes to the external system's data structures from adversely impacting your system performance and data quality.

Reporting. The only constant in business is change. This change can be with employees, systems, and data. After a recent organizational change, you find yourself the sole developer supporting a system that you did not write. Although the documentation was kept up to date regarding code and migration, the data interconnects on the enterprise were never developed. To ease you into your new job, you can run a report to identify all interrelated data connections as well as mappings within other systems (transformation and reuse). This helps you to further develop technical and business contacts and schedule your next release in a timely and effective manner. This same technique can be utilized when transferring data for outsourcing and/or offshore support.

Keep The Business Running (KTBR) Staff
Impact Analysis. As part of a new security measure, you are given the task of ensuring that all the Database Management Systems (DBMS) for systems you manage and interface with, have been updated to the newest versions of DBMS. Short of logging onto each system, there is no other way to perform this. However, with real-time components of a Metadata Repository, cataloging of application systems and environments are enabled and maintained accurate.

Reporting. You have discovered that a server has a faulty power supply causing the whole server to burn up during the night and go offline. The damage was so extensive that even the parallel storage system was destroyed beyond recovery. Adding to this problem, your cataloging system, which contains server versus application and data, was hosted on that server. Not knowing what customer contacts to utilize regarding the outage, recovery frustrations rise as application users start to flood the help desk and bog down engineers attempting to locate backups in hopes of restoring the systems. A simple roll-up of server-based data stores, application systems, and related transformation objects can be done per server. Through related Metadata objects, a simple discovery of

application owner and linked data stores (upstream and downstream) should help in notification and contingency planning for the recovery.

Security/Auditing Staff

Impact Analysis. Recent changes to governing policies have made the task of knowing the type of data you have and where they are stored a very high priority. Regulations now require you to secure employee phone numbers from all systems other than HR source systems. Historically, auditing the locations of this information requires manual interviews and data discovery processes. The only piece of information you have is the HR source system. Through the use of a Metadata Repository and intelligent impact analysis, you would be able to crawl the relationships and discover all related systems that this information was fed into and delivered from as well as ROO contact information in order to obtain data not readily available.

Reporting. A new federal policy has been passed by Congress requiring that people with access to personnel addresses should not be allowed access to sales customer databases. It has been shown that cross-referencing this can help to identify people who work for a company and also consume their products, which has led to actual acts of prejudice against those that do not consume their own company's products. In the past, a simple analysis like this would have taken weeks to perform. All interrelated systems had to be crawled, analyzed, documented, and validated. The Metadata Repository by itself does not provide this functionality. However, when the targeted data stores are identified, and coupled with a Role-Based Access Control (RBAC) system, you can easily flag conflicts and put in place rules to prevent this from happening in the future.

Acquisition Coordinator/Manager

Metadata Reuse. Because you have been acquired by a new company, several disparate applications have been marked for integration into the enterprise in order to more easily integrate new employees and their associated processes. Simple analysis discovers similar systems already inside the enterprise, and based upon data structures in both systems, you can easily engage with the source system to coordinate a data migration and integration effort.

Program/Project Manager

Impact Analysis. Prior to last year, you had been using a legacy application to track shipping information related to hazardous chemicals coming into and leaving the property. With the integration of this information into our enterprise shipping applications, it is now necessary to end the legacy system (and data) and concentrate your efforts on your new system. Your legacy system had been integrated into dozens of applications and reporting structures over the last seven years, and the analysts who helped perform these tasks have moved on with little or no documentation. A primary tenet of an Enterprise Metadata Repository is the integration of ROO data related to applications. This information is the first step towards accurate mappings-related data consumed by that system as well as mappings between data sources and reused objects.

Reporting. Executive staff have communicated the need for increased reuse with a subsequent decrease in single-use, non-reusable systems and environments. Your task is to identify systems that exist in a silo. Applications or data stores that have no data input and no data output are of zero reuse benefit to the company. After identification of these systems, you are given the task of identifying additional redundant systems that perform the same function. Your end state is to consolidate these systems in the hopes of increasing reuse and decreasing isolated data stores. The reporting aspect of the Metadata Repository can help to identify systems with no interconnects to data stores or applications. Categorization of these items can help to identify trending possibilities and through some subsequent analysis, overlaps in functionality will bubble up. This analysis which used to take months and was limited on penetration, can be done in minutes and can scope the entire enterprise. Isolation is no longer required when reuse is allowed.

BENEFITS OF METADATA MANAGEMENT AND METADATA REPOSITORY IMPLEMENTATION

There are several benefits associated with investment in a robust Metadata Management program and associated Metadata Repository. These include increased reuse of your corporate assets, improved impact analysis associated with these assets, increased quality for decision-making, reduced development and maintenance time, greater success in deployment of new enterprise capabilities, improved user access/usage, and better understanding of your corporation's assets. For corporations pursuing Enterprise Architecture, Metadata serves as the interstitial glue that links business processes to data to applications to the technical infrastructure. Some of the important benefits of the Metadata Management are discussed below.

Enabling Reuse of Corporate Assets

To increase reuse value, you must have a consistent set of Metadata attributes captured about all assets targeted for reuse. Examples of Metadata attributes might include author, definition, creation date, technology, and expiration date. This Metadata defines the key attributes of the corporate assets available for reuse and, through

this Metadata, corporations can realize significant reductions in Total Cost of Ownership (TCO), drive reduction of redundant assets, and enable agility through maximized return and increased utilization of their unique corporate assets. Reuse benefits through effective Metadata capture about corporate assets can also enable more consistent business process implementation and accelerated Enterprise Architecture adoption as the associated assets can be leveraged for subsequent instantiations. This is especially important when corporations want to maximize their resources on new capabilities versus reinventing existing assets due to lack of knowledge of their existence. Industry data has shown that upon discovery of reusable assets, the cost of reusing the asset is approximately 20% of the cost of creating the asset anew. Using a Metadata Repository also increases the impact of the reuse paradigm within corporations from one of ad hoc reuse (based on analyst, developer, or engineer interaction) to an enterprise-wide prescriptive reuse capability (where all assets are made available and mapped to the Enterprise Architecture for quick assessment and implementation).

Improved Impact Analysis

Enterprise data volumes are doubling every 12-18 months–this data explosion is fueled by data from inside corporations, data throughout the supply chain, and data from new sources. Likewise, the data growth is further exacerbated by the rapid adoption of XML as XML is roughly 10%-20% less efficient (in terms of size) as an interchange standard. Today's enterprise infrastructure is poorly suited for dealing with this continuing, rapid explosion in data and must rely on Metadata to maintain a manageable view of corporate assets. Through Metadata, a simplified infrastructure and a move toward a services-oriented architecture are essential to provide the needed impact analysis and associated business intelligence on this data growth that is both cost effective and timely.

Examples of Metadata captured for impact analysis, such as those discussed in usage scenarios, include the following:

- Business Metadata definitions and business rules.
- Data Metadata definitions.
- Data transformation rules, mappings, and processes.
- Data lineage (from models to database/tables to report usage).
- Application Metadata definitions.
- Technical Metadata definitions.
- Dependency across business processes, data, applications, and technology.

Without this impact analysis, Metadata analysts, developers, and engineers must spend an enormous amount of time in discovery mode searching out assets and then uncovering the relationships between assets; only a finite amount of time remains to put the asset(s) to use. To invert this 80% research and 20% deployment paradigm, and thus improve the user's interaction with corporate assets and raise productivity, companies must focus on the Metadata Management processes to collect this impact analysis Metadata (including the definition AND its context in the overall enterprise).

Increased Data Quality for Decision-Making

Corporations are quantifying the costs they are incurring due to inadequate, inaccurate, or incomplete data that has a direct correlation with the quality of decision-making. At the core of these problems lies a lack of rigor around the definition of data and their characteristics, or Metadata. By establishing Metadata processes to ensure needed Metadata definition and capturing this Metadata in a centralized Repository, Metadata Management ensures data consistency, thus enabling better business decisions. Corporations have identified data quality as key to their success, and have identified credible Metadata as the cornerstone of information quality.

Reduced Development/Maintenance and Increased Success in Enterprise Deployment

Metadata Management streamlines the application development process by reducing the development, deployment, and maintenance costs. This is made possible by the use of a single source of Metadata for logical, physical, and process aspects of the application environment, while tracking versions of the code and documenting all aspects of the application development life cycle. By providing a complete, integrated view of the development environment, Metadata helps identify redundant processes and applications, thereby reducing duplicated efforts. Developers can share and reuse existing objects such as data structures, programs, model definitions, and more. In addition, Enterprise Impact Analysis greatly reduces the analysis and maintenance phase of the development life cycle.

An example of measured results reported by one of the development teams within Intel's manufacturing group found that, based on Metadata reuse, for every $1 invested in using the Metadata Repository, $6 was saved in reduced development and sustaining costs for their Decision Support Systems (DSS) applications. Meta Group's recent "Data Warehouse Scorecard and Cost of Ownership" industry study quantified the enormous effect Metadata has had on the overall success of data warehouse initiatives. It reported that 75% of highly

successful data warehouse initiatives included formal Metadata Management facilities.

Metadata is also the foundation of effective enabling of future initiatives such as model-driven, event-driven, service-oriented architecture, Service-Oriented Development of Applications (SODA), Metadata-driven entitlement/security and role-based access control, and next-generation business intelligence architecture. "Through 2008, enterprises that use a Metadata Repository as part of a reuse program can develop SODA applications at least 20% more quickly and less expensively than those that do not (0.8 probability)." [1]

Understanding Corporate Assets through Metadata

Establishing an understanding of corporate assets via Metadata Management processes and a centralized Repository can benefit business users as well as the Metadata-producing organizations within a corporation. By providing a Metadata "card catalog" and implementing an enterprise data dictionary, business users can find processes, data, applications, technology, and reports more easily. In addition, the Metadata-producing organization can record the knowledge about assets for future use. As personnel change within an organization, institutional knowledge can leave that organization and undocumented assets can quickly lose their meaning and/or value. Subsequent employees may have little or no understanding of the corporate assets and may find they can't trust results generated from these assets if there is no context. This is especially important for documentation on legacy assets.

CONCLUSION

Corporations are beginning to see the value of Metadata to the business, and not just as a technology asset. Corporations that develop enterprise architecture frameworks that tie together business strategies, business processes, and data and instantiate the applications and supporting technologies based on those processes/data will benefit from Metadata Management. By focusing on Metadata Management processes, Intel expects to continue its approach to using standard deliverables defined with repeatable development processes to capture credible Metadata, and integrate that Metadata into the enterprise architecture framework. Over the past six years, since forming a centralized Metadata capability at Intel, Metadata usage and importance has increased in our environment. Since the latest iteration of our Enterprise Metadata Repository, we have seen a 400% increase in its utilization. We have also had a subsequent request for newer and better functionality in order to engage usage methods and customers that we had not initially realized would find value in the tool.

Metadata must be managed to be of value and connected to increase value. The value provided by a Metadata Management program will accelerate over time as the enterprise architecture framework continues to be built out and deliverables providing credible Metadata content are incorporated. Continued engagement in all project starts guarantees that Metadata gathering methods are employed up front, and our automated methods for refresh are put in place early. The best Metadata is accurate Metadata always. For further reading, see references [2-7].

ACKNOWLEDGMENTS

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AUTHORS' BIOGRAPHIES

Thiru Thangarathinam has been with Intel for two and a half years and has extensive experience in architecting, designing, and developing N-Tier applications using Service-oriented Architectures and related technologies. Thiru is currently the application architect of the Enterprise Metadata Repository application within Enterprise Data Architecture. He was part of the team that recently developed Intel's Metadata Repository and implemented the Enterprise Metadata Repository. Thiru has also coauthored a number of books on Service-oriented Architectures and has also been a frequent

contributor to leading online technology-related publications. His undergraduate degree is from The College of Engineering, Anna University, Madras. His e-mail is thiru.thangarathinam at intel.com.

Gregg Wyant is the chief data architect and director of Enterprise Data Architecture in the Information Services and Technology Group. With more than sixteen years at Intel, his career spans architecting Intel's early desktop and mobile solutions to driving software vendor optimizations for processor instruction set enhancements, to authoring the Ziff-Davis book *How Microprocessors Work* (translated into seven languages and used as the basic primer for Intel technology). He holds a B.S. degree in Computer Engineering from Iowa State and an MBA degree from California State University, Sacramento. His e-mail is gregg.wyant at intel.com.

Jacque Gibson has been with Intel for fourteen years and has experience in Production Planning and Information Technology. As manager of Product Data Management, she participated in Intel's initial ERP implementation. Jacque is currently the manager of Metadata Services within Enterprise Data Architecture. She and her team recently developed Intel's Metadata Program and implemented the Enterprise Metadata Repository. Her undergraduate degree is from Michigan State University. Her e-mail is jacquelyn.a.gibson at intel.com.

John Simpson is the technical programming lead and project manager within Enterprise Data Architecture for the Information Services and Technology Group. In his ten years with Intel he has moved from factory support services into Information Technology, launching one of the first database-driven applications on the company Intranet. His undergraduate degrees are from the University of the State of New York and the University of Phoenix, from which he also holds an M.S. degree in Computer Science. His e-mail is john.e.simpson at intel.com.

All of the authors are part of the Enterprise Data Architecture's Metadata Services team that recently won the 2004 DAMA/Wilshire Award for "Best Practices in Metadata Management" at the DAMA conference in May 2004. This is the highest award given in the data management industry for Metadata practices, and it is given to corporate data organizations to recognize business value, innovation, and excellence in design and/or implementation of Metadata as a critical component in data management success. Intel was selected as the winner based on the specified corporate cost reductions and productivity improvements as well as on its implementation of corporate data management practices.

The award press release and details can be found here: http://www.wilshireconferences.com/award/index.htm. Data Management Association (DAMA) International is an international not-for-profit association of data resource management professionals. DAMA International's primary purpose is to promote the understanding, development, and practice of managing information and data as a key enterprise asset. With presentations on topics ranging from Business Intelligence to Data Quality to Enterprise Architecture to Process Modeling, industry experts and corporate practitioners shared their strategies and success stories with the conference attendees.

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