Managing Materials Information in the Supply Chain

Having ready access to product material information within a given supply chain has become an important business requirement to participate in today's global economy. Material information is needed to address a variety of business concerns, from regulatory compliance to environmentally conscious design. Reliable communication and management of material data is difficult to achieve due to different regional regulations, distributed supply networks, and the wide variety of risk-management practices. All of these factors combined make managing material information across the entire supply chain extremely complex.

One way to address this complexity is by developing robust data exchange standards to support material composition declarations. Properly designed, data exchange standards can reduce the difficulty of exchanging this information and ease integration with diverse data management systems. Using rigorous, systems-development approaches, such as those used in the software development industry, will help ensure that the standard captures the necessary scope and requirements. Furthermore, to facilitate better integration between the material data exchange and the associated material information systems, tools can be used to generate software code and database structures directly from the underlying system representation (often called a "model"). This leads to a number of benefits including a shortened development process, a likely reduction in program and database errors, and a more robust system that is more accommodating to future changes. Should changes be made to the underlying system, new code can be automatically generated from the new model.

The IPC 1752 version 2.0 Materials Declaration Management standard (part of the IPC 1750 Supplier Declaration Series) was developed using this structured, model-based approach to standards development. The IPC 1752 version 1 was created in 2006 to help the electronic industry comply with the European Union's Restriction of Hazardous Substances [RoHS] Directive and other environmental regulations. IPC 1752 version 2.0 is an update to this standard; it adds improved handling of multiple parts in a single declaration, support for XML signatures in the data exchange file itself, and better tools to support industry adoption of the standard. The update to the IPC 1752 also provided an opportunity to showcase the new development process and a chance to prove that it actually works to create a viable industry standard.

Material Information System Complexity

Within the electronics manufacturing industry, every company has its own information management mechanism. The systems used for this range from purely manual organization to fully automated product data management systems. Now that outsourcing is common in the electronics industry, the material information may be exchanged between two companies that have both vastly different systems and business processes. If the two systems and processes are not designed to interoperate with each other, the conversion between the two can result in lost or erroneous data.

On top of this, the electronics manufacturing domain introduces additional complexity due to the variety of localized environmental regulations. Environmental reporting is made more difficult due to these local regulations having different material reporting requirements. Environmental regulations passed in one country can impact companies around the world. Therefore, companies must be capable of managing information requirements for all of their potential product markets.

The complexity is further increased due to different business approaches to mitigating risk associated with this information. Suppliers at low risk of non-compliant products may only ask for a simple yes/no declaration, while companies with higher risk may require full product composition information so that they can perform additional verification to ensure compliance.

Just imagine trying to manage material information in a supply chain in which each member requests a particular (often overlapping) subset of the available information, with each request in a different format. This was the situation many companies faced before RoHS went into effect -- getting hundreds of similar material information requests in a variety of formats that all needed to be processed individually.

The development of a meta-system that can handle this level of complexity requires a close look at the process of developing data standards and how to implement them.

Data Standards Development

The complexity of the material information domain means that traditional ad-hoc standards development processes result in inadequate standards. For example, having numerous domain experts with different priorities developing the standard often leads to standards that are overly complex (contain unnecessary information), oversimplified (missing important information), or difficult to implement. By learning from the success the software industry has achieved using a structured development approach, new standards may be developed in a way that both accurately captures the domain information and aids in the development of data management solutions.

The first step is to do a comprehensive study of the scope the standard is to cover and accurately record the business requirements. Systems modeling languages, such as Unified Modeling Language (UML), allow the relationships entities within the domain to be accurately captured, and use cases to be developed based on the actual business requirements.

Next is the design model, which refines the analysis model to focus only on the data exchange elements. The design model describes, in detail, the structure of the proposed system (in this case, the data exchange standard) taking into account how it will be implemented. An important benefit of this approach is the ability to use the UML design model to generate relational database schemas, software classes, and even XML schemas. These two parts -- the design class diagram and the code structures created from the diagram -- are the primary outputs of the new standards development process.

Finally, software tools can be used that will allow standards developers to automatically generate object oriented software code, schemas for relational databases, and schemas for XML instances directly from the UML models of the standard. While this method sounds complex, it should be noted that even a subset of the proposed methodology would provide significant benefits. This was the approach applied to IPC 1752 version 2.0 and is shown in Figure 1.

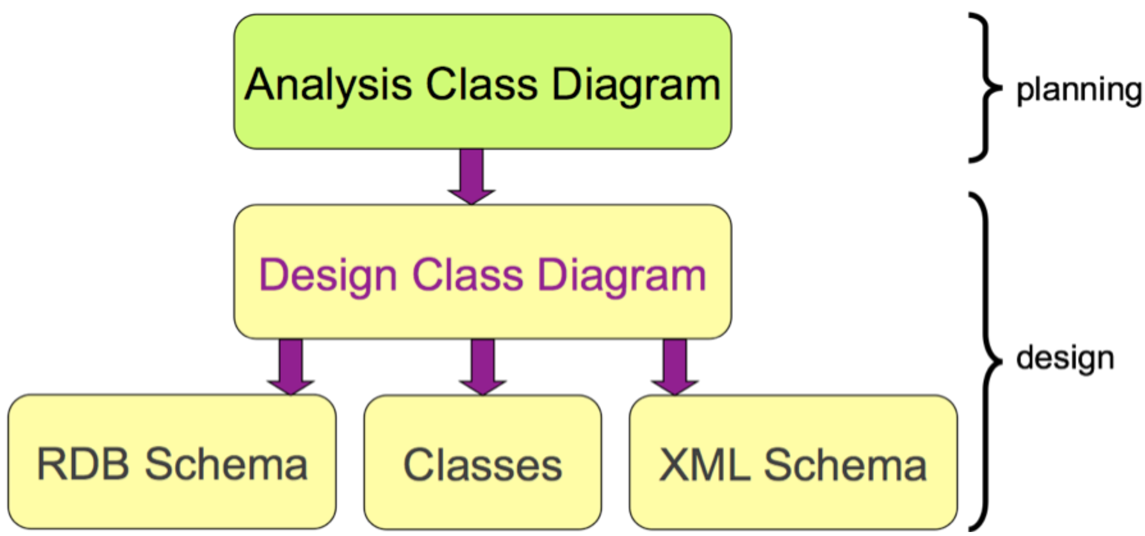

Figure 1.

Implementation Development

The basic data management system can be broken down into four basic components: 1) the data input for the system, 2) the data archive where that data is stored, 3) the routines to manipulate the data (edit, delete, etc.), and 4) the output to extract data for analysis or exchange.

Figure 2 shows the relationship between the elements of a basic data management system (DMS). This system supports data import and export, has the ability to store data, and has the ability to extract and modify the data. The system can take input in two forms, either directly entered into the system or imported from an XML file. The data is then placed in an archive for storage and can be loaded into memory for manipulation using programmed routines. The data can also be extracted from the system for review or sent to the next link in the supply chain.

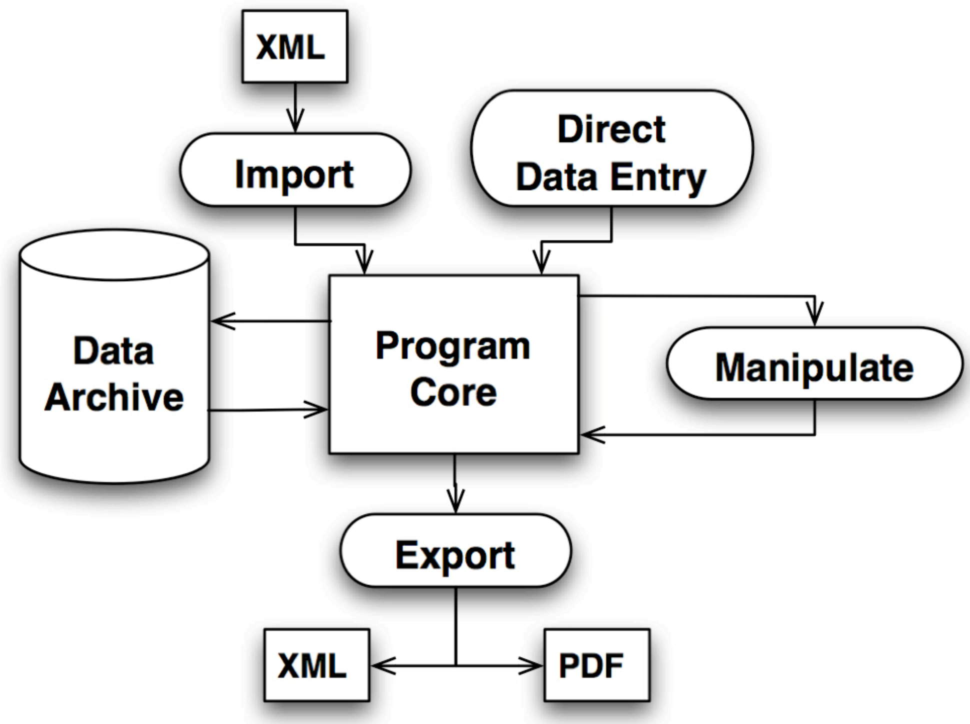

Figure 2 Basic DMS Layout.

Example Implementation

The NIST Electronic Information Group wanted to demonstrate how simple it is to create a basic DMS using this approach, so we created a prototype data management tool for IPC 1752. The team developed a basic data manipulation tool and matching database based on the 1752 design model. The first step involved the creation of the software tool designed to provide basic CRUD (Create, Read, Update, Delete) functions, as shown in Figure 2. The tool (named Scriba) was developed using the Java programming language to simplify cross-platform deployment and provides a graphical interface that allows users to view and modify material information in the IPC 1752 format. It is worth noting that the Scriba software is fully in the public domain and the source code is freely available to incorporate into other software products.

Once Scriba was complete, a matching database to store the generated XML files was built. To achieve this, software was used to generate a relational database schema from the 1752 design model. The resulting schema defines the structure of the database and was used to generate a relational database using a freely available database package. Since the design model was the template for both the XML data exchange and the relational database, the table structures, relationships, and data types match exactly the structure and data types in a 1752 XML instance.

Conclusion

Managing material information in a distributed supply chain is quite challenging. Whereas it can be addressed individually between any two partners, as the supply chain expands to become a complex network, information management becomes very difficult. The IPC 1752 standard was created to help minimize this complexity and also provided an opportunity to try out an improved data standards development process. NIST successfully built a complete (if simplistic) data management system using the output from the improved standards development process. This proof of concept provides industry with both an improved material information data exchange standard and a method for improving the development of future standards.