Open Standards-based Software Tools Optimize the PCB Manufacturing Enterprise

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Introduction

Today's Electronic Manufacturing Service (EMS) providers and Original Equipment Manufacturers (OEMs) are faced with the challenge of managing data transfers between disparate systems in a manner that guarantees data completeness and correctness while minimizing cost. Data sources include Computer-Aided Design (CAD) systems, Computer-Aided Manufacturing (CAM) software solutions, and Enterprise Resource Planning (ERP) systems. These must provide data to target systems such as bare-board and fixture manufacturers, manufacturing assembly systems, In-Circuit Test (ICT) and Functional Test (FT) systems, and repair stations.

Complex bi-directional data transfer, such as that shown in **Figure 1**, needs to take place between the design shop, the bare board fabricator, the assembly house, and the test fixture house in order to maintain information synchronization and ensure the quality of the final product. The main obstacle to accomplishing this is that each system generally expects information to be generated or provided in its own proprietary data format. This has lead to a variety of tools and system options whose sole purpose is to translate data between the formats required for each system. Each time data is translated from one format to another the possibility exists of losing either a portion of the actual data itself, or the meaning of the data being converted.

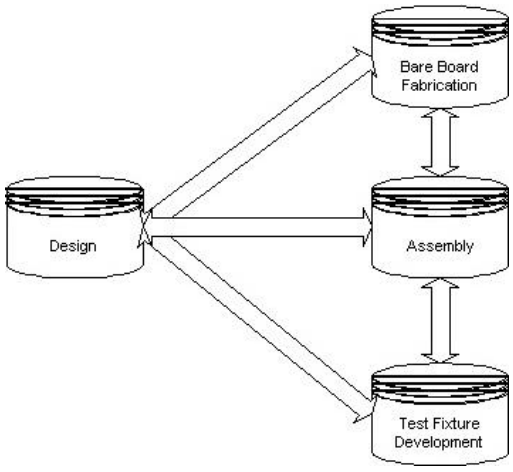

Figure 1 – Typical Data Flow

In a world where communications boundaries are breaking down and organizations are discovering revolutionary new ways to securely and efficiently transport data directly between businesses, suppliers and consumers, the issue of data transfer formats has become one of paramount importance. Product complexity is increasing, while decreasing product life cycles are driving corresponding increases in the rate of New Product Introduction (NPI). The inherent information loss and labor associated with data format conversion leads to a reduction in quality and increased lead times, extending time to market and directly impacting the NPI profit curve.

The days of generating Gerber RS-274-D (or the extended RS-274-X) photo-plotter files from a CAD system for use by a manufacturing organization are long gone. Classical layer-based proprietary formats may have been sufficient when system data transfer involved little more than sending artwork information to a bare-board manufacturer, but this is no longer the case. Data formats must now support object-oriented data storage of true manufacturing entities such as complex padstacks (**Figure 2**), components, fixtures, boards, panels, drawings and assemblies. According to a recent industry study, the data transfer issues facing today's manufacturing enterprises are costing US corporations over $150 million a year. Customers and suppliers are demanding a solution to the proprietary format issue in the form of an up-to-date vendor-independent standard that addresses the complete data transfer needs of today's manufacturing environment.

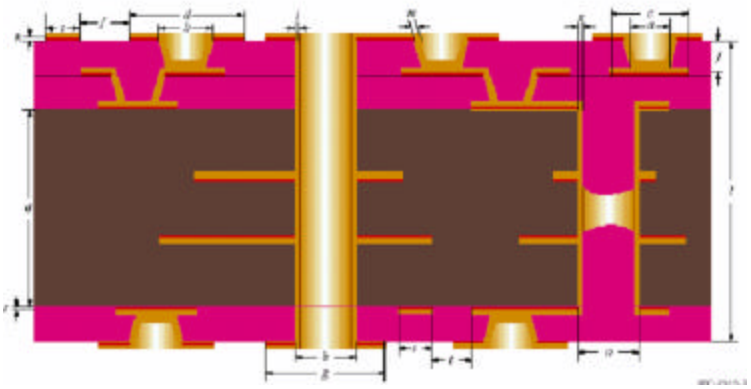

Figure 2 – Complex Padstack Representation

Open standards provide the solution to the data transfer issue. Non-proprietary data formats designed by committees of industry representatives deliver depth, coverage and widespread industry acceptance. Software tools developed to support these standards can provide customers and organizations the improved quality and reduced costs they demand. This article discusses the benefits of open standards from both a customer and vendor's perspective, and discusses the new IPC GenCAM standard that aims to address the data transfer problem in the bare-board (also called Printed Circuit Board - PCB) and populated-board (also called Printed Circuit Assembly - PCA) market sectors.

Background

The requirements given to developers by a product line have historically focused on solving discrete customer needs rather than examining the issues facing the entire enterprise. This perspective allowed a developer free reign to choose from a wide variety of storage options, from relational or object-oriented databases to flat or structured file systems. From these requirements the developer identified the units of data to be stored and examined possible storage schemas. With little to choose from in the industry in this area, most vendors developed their own proprietary formats founded primarily on prior experience.

Over time, these formats are added to by new data requirements, expanding them beyond the scope of their original design and moving them into areas where the schemas begin to become less optimized and flexible. New developers working on the format may implement capabilities in a manner that conflict with the original intent of the schema. This makes the format more cumbersome to work with such that new application development and maintenance becomes increasingly difficult and expensive.

From a vendor's point of view, a proprietary standard is an ideal way to ensure customer lock-in. A customer may purchase a large number of a particular vendor's tools to solve a particular need. As products are processed through these tools, the vendor's proprietary

data files are stored, managed and archived by the customer for traceability. Many customers go so far as to "standardize" on the proprietary format internally to minimize data transfer and conversion costs. The cost to a customer to move to another vendor's tools is considerable, adding substantial infrastructure change costs and legacy support costs to the training and capital expenditure charges. This deters many customers and provides a continuous software support revenue stream to a vendor, which results in reduced pressure on the vendor to provide competitive tools and value updates.

In order to provide deep penetration into a market space with a proprietary data format, a vendor must form partnerships with other vendors and suppliers to ensure the data format may be read or written by a variety of systems. The more systems that support the format the greater the chance of lock-in and increased revenue streams.

In the early 1990's the Mitron Corporation, a leading provider of CAM software tools and now a subsidiary of GenRad Inc., developed a proprietary data transfer format called GenCAD. All Mitron tools were modified to use GenCAD as the means of obtaining data from CAD systems. In order to increase integration capabilities, Mitron partnered with Router Solutions Inc. (RSI) to provide CAD translation tools from multiple CAD systems to the GenCAD file format. This approach, coupled with open publication of the format schema, resulted in the GenCAD file format becoming the most widely used structured CAD format in the assembly, test and inspection industry today.

However, the GenCAD format was designed almost ten years ago when object-oriented programming and object/data extensibility was in its relative infancy. It was not intended to support true, hierarchical manufacturing data such as schematics, drawings, assemblies and fixtures. Attempting to extend the format to support these features while maintaining legacy support for its 2D roots would result in format degradation. The same holds true for extending the photo-plotter bare-board Gerber RS-274-D format or any other layer-based, legacy technology format into the complex manufacturing environments we live in today. What may have passed as a viable approach ten years ago is no longer the case.

The IPC GenCAM Open Standard

In March 2000 the Association Connecting Electronics Industries (IPC), an ANSI accredited standards organization, released the IPC-2510 series of documents which comprise a new manufacturing data transfer specification known as GenCAM. The standard was founded on the primary strengths of the GenCAD format, donated by GenRad Inc. to the IPC standards committee in 1996, but re-designed to support all PCB and PCA manufacturing requirements. The IPC's Data Transfer Solutions committee, consisting of representatives from over 40 organizations, developed the GenCAM standard over a four-year period as the solution to the proprietary data transfer issue. These organizations covered all areas of the manufacturing arena, including CAD vendors, sub-contract manufacturers and end-users.

Whereas Gerber RS-274-D became a "standard" due to its simplicity and rapid adoption at a time where there was no alternative, GenCAM is the realization of a true open standard proposed, developed and supported by a standards body of industry-wide experience. It promises to open the doors to seamless manufacturing application interoperability. Customers will be able to choose from a large number of GenCAM-enabled products in the industry to combine a suite of tools that best meet their own specific requirements.

In addition, GenCAM is future-proof. The format is extensible, allowing it to support new requirements as they arrive, and the strengths of its object-oriented data description schema ensures that it will continue to meet the needs of the PCA and PCB industries for years to come.

For more information on GenCAM, visit the official web site at http://www.gencam.org/.

Open Standards Benefit Customers

For the customer, open standards promote a marketplace of choices driven by customer demand rather than proprietary data reliance. Whereas a vendor may maintain a comfortable portion of market presence due to wide adoption of their proprietary format, industry adoption of an open standard instead refocuses attention on the capabilities of the vendors' application functionality. GenCAM promotes competitiveness so that vendors can no longer expect customer lock in simply due to a proprietary format. Tool suppliers will need to provide innovative solutions with impeccable GenCAM support to maintain their position in the marketplace.

The customer will experience improvements in quality and a reduction in labor costs. Most CAD vendors implement a proprietary data format for transfer of data between their systems. This data format is also used to drive manufacturing software processes, often via some form of translation to the format required by the software vendor. This translation is often error-prone and results in loss of data fidelity due to the fact that one or both formats regularly only provide support for a sub-set of the other. GenCAM is a super-set of each of these systems rather than a sub-set. Native creation of a GenCAM file from a CAD system, passed into an application with native GenCAM support, ensures high data fidelity and eliminates transfer errors. Quality is improved and labor reduced due to the completeness and correctness of the data.

The customer also experiences a reduction in expenditure. No longer will they need to purchase multiple conversion or translation utilities for each system that they need to pass data between. All they need do is demand GenCAM support from each system.

Open Standards Benefit Solution Providers

It would be naïve to expect that an industry-wide open standard would support the complete discrete data storage needs of all solution providers. Instead, the strengths of such a format may be leveraged and built on to *reduce* the proprietary data storage requirements of a vendor. This has enormous benefits for vendors and customers alike.

A vendor does not need to spend significant resources designing and developing their own schema definition based on requirements from the customer base and product lines. Any one vendor's definition of a data storage schema is unlikely to fulfill the needs of a complete marketplace as it is based on the niche area of the market that they operate within. Over time it would need to be extended to move into new market areas, a process that often results in a non-optimal solution. Adoption of an industry-wide schema defined by a standards committee with more experience and knowledge than any one vendor will reduce development costs while offering capabilities that the individual vendor may not have considered.

The vendor benefits from several resources supplied at no charge by the standards organization. To ensure adoption and rapid implementation, open standards are extremely well documented. The complete GenCAM 1.5 specification is almost 200 pages long with examples and illustrations throughout. This provides a developer with highly detailed information on the data schema he needs to support in a standard documentation format. This is in contrast to proprietary data formats, where the schema

documentation is often limited, proprietary in structure and rarely enriched with examples and definitions.

IPC also provide a Compliance Test Module (CTM) to determine the conformance of GenCAM files to the standard. The CTM checks for format and cross-linking correctness, including keyword and parameter validity and presence. This eliminates one of the main obstacles facing developers when creating format handlers, that of identifying errors due to non-conformance of the file to the format. The CTM may also be used by customers to determine compliance of the GenCAM files they receive or supply.

An open forum is maintained by the standards committee members to provide support and feedback for developers. This open promotion of information sharing is in sharp contrast to the difficulty often encountered when attempting to obtain format support from a proprietary vendor.

Although any new standard will experience some interpretation obstacles during its initial adoption, the quality of the GenCAM documentation, the availability of the CTM and the open forum of users and supporters has already lead to rapid implementation of some high-quality GenCAM solutions by several vendors.

A Commitment to Open Standards

As a leading IPC contributor, GenRad is strongly committed to the development and implementation of open, non-proprietary standards and solutions. As an organization, GenRad realizes the benefits of implementing standards-based data storage and transfer functionality in its solutions to reduce its own infrastructure costs while delivering strong interoperability with other enterprise systems.

In June 2001, GenRad released a new version of its GR Force/D2B™ product suite (**Figure 3**), the first software product in the industry to receive IPC certification for compliance to the GenCAM standard. This is a product constructed to use GenCAM as its primary data storage solution in an open, extensible architecture. As the portal to its complete range of software and hardware product solutions, GR Force/D2B™ provides GenRad's with complete GenCAM support across the manufacturing enterprise. The unprecedented capabilities of GRForce/D2B™ enable EMS's and OEM's to interconnect their global enterprises to optimize operating efficiency and profitability. As a further indication of GenRad's commitment to GenCAM, this interactive graphical environment is available at no charge in read-only form for viewing files in both the GenCAM standard format and the widely used GenCAD format. For more information visit GenRad's home page at http://www.genrad.com.

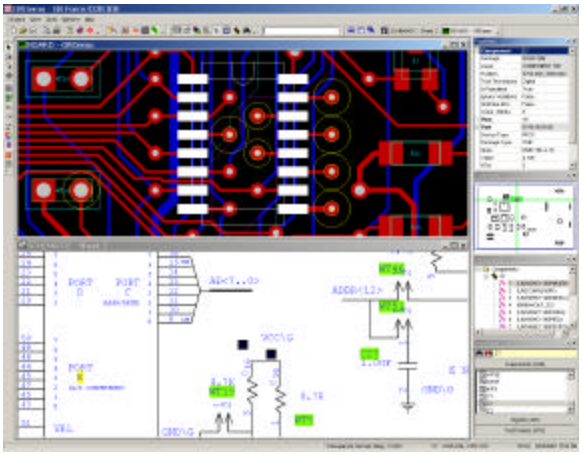

Figure 3 – GR Force/D2B™

GR Force/D2B™ was originally intended to replace the functionality of GenRad's CB/Test manufacturing test program and fixture generation tool. The original design made use of existing technology, including a GenCAD API and the CB/Test graphical editor. Shortly

into development the first draft of the GenCAM 1.5 specification was released. At that time, a decision was made in GenRad to change the direction of the product and transform it into a complete graphical manufacturing data preparation tool. The GenCAD API was discarded and a new, highly optimized GenCAM API and graphical engine developed. The impact of the change was offset by the benefits of greater product functionality, reduced internal engineering support costs and an open, rapid development platform built on an industry standard.

The primary GR Force/D2B™ project GenCAM file is supplemented by a smaller, proprietary project data file used to store additional information such as user preferences and algorithmic rules. The GenCAM project file stores all manufacturing project, information, including multiple schematics, panels, fixtures and boards. High quality GenCAM support is inherent in the application as the data is stored in its native object-oriented format, bypassing costly conversion of formats. All optional tools that run under the GR Force/D2B™ framework, including the BOM reader, fixture design wizards and algorithms, design for manufacturing rules and the latest multi-machine test and fault distribution algorithms operate on this native GenCAM data. Legacy system supported is provided by translators from multiple CAD vendor formats to the GenCAM standard format.

GenRad has also worked closely with other vendors to develop high-quality GenCAM outputs from major CAD systems. Together with the GenCAM documentation and the CTM, GR Force/D2B™ has become an essential, freely available development aid for vendors wishing to support GenCAM.

Conclusion

Open standards are the new paradigm of the software world. Open source operating systems such as Linux, open standards data description languages such as XML and open standards protocols such as XML-RPC and SOAP are changing the way systems are architected and developed. Software solution providers worldwide are recognizing the need to re-architect their products to support the latest open standards to maximize interoperability with other systems. In this new environment, those who demand open standards support will reap the rewards of winning in the global marketplace.