USING A PLATFORM APPROACH TO INCREASE THE AVAILABILITY OF MATERIAL DATA FOR CAE

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THEME

Simulation Data Management

KEYWORDS

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SUMMARY

The sourcing and dissemination of material properties for use in CAE is a neglected area of simulation data management. As analysts continue to use more sophisticated material models to describe the behaviour of complex materials used in product development, they are faced with the need to obtain properties that go beyond the typical single point material properties commonly available today. The usual free Internet sources are unable to meet the demand for this kind of data because it is considered high value in nature and therefore, not for general consumption. Additionally, lack of traceability adds a layer of risk that is untenable for design communities. Yet, it is undeniable that CAE analysts must have access to quality material properties. The problem is particularly aggravating when the properties are actually in existence but the analyst does not know who to ask or where to look for such data.

A solution lies in a platform approach where it is possible to exploit the power of the Internet coupled with Web 2.0 concepts to facilitate the exchange of this kind of information. A web-based platform is used to deploy a number of private material databases belonging to different companies. Each database forms a common source for all individuals within the company to locate and deploy material properties irrespective of their global location. Controls can be put in place to ensure that the data is properly used.

Since it is customary in today's product development environment for companies to work in a collaborative manner, discovery tools are provided to permit platform users to locate data of interest that might exist within other material databases located on the platform. These might include databases of material suppliers and development partners. Access to such data is regulated, by requiring the granting of permission when an access request is received.

Typically, access will be granted when the owner of a database recognizes the requestor as a collaborator in their development process.

Conversely, a Data Sharing approach is also used where the database owner sends a data link to the collaborator. These forms of data communications are much preferred over the conventional e-mail attachment because the data is not in circulation itself but is accessible only to the person to whom permission has been granted. Additionally, the information is presented in a rich environment where the data can be viewed, analysed and post-processed within a material data-intelligent web interface.

The material data-intelligent web interface greatly enhances the ability of the analyst to assimilate and understand the material data that they are using for important design decisions. Modern day material properties capture dependencies on a number of variables such as rate, time, temperature, pressure and the environment. Visualizing such complexity using simplistic tools such as Excel is frustrating and time consuming. Here, a click of the button approach presents all the possible dependencies existing in a dataset. The presence of the pedigree information related to the data adds confidence regarding the suitability of the data for the purpose at hand.

A critical component of material data is usability. Much too often, CAE codes require the data to be converted into forms that are different from the raw data. This process is intimidating for most CAE analysts. It is also error prone because of the lack of clear guidelines for the conversion of the data. The material data-intelligent web interface has built-in tools to perform these data transformations with simple user interfaces to guide the analyst in the creation of their material data cards.

1: Introduction

The sourcing and dissemination of material properties for use in CAE is a neglected area of simulation data management. As analysts continue to use more sophisticated material models to describe the behaviour of complex materials used in product development today, they are faced with the need to obtain properties that go beyond the typical single point material properties commonly available today. The usual free Internet sources are unable to meet the demand for such data because it is considered high value in nature and therefore, not for general consumption. Additionally, lack of traceability of traditional Internet properties adds a layer of risk that is untenable for design communities. Yet, it is undeniable that CAE analysts must have access to quality material properties. The problem is particularly aggravating when the properties are actually in existence but the analyst does not know who to ask or where to look for such data.

In previous work, [1] we presented a material data management system that allowed companies to consolidate the materials knowledge of the enterprise and then disseminate it selectively within the organization. The idea of scaling this concept to aid collaboration between enterprises has evolved from here resulting in the development of a web-platform to securely host the material databases of a large number of companies, while facilitating selective data sharing in keeping with the business practices of each individual enterprise.

In this paper, we present the elements of this solution based on a platform approach where we exploit the power of the Internet coupled with Web 2.0 concepts to facilitate the exchange of this kind of information. We then look into the issues related to utilization and access to data, privacy and control of data assets. Finally, the issue of usability of data is considered where we look at what it takes to make data available to wide variety of downstream third party applications.

2: Web Platform Elements

The **web-platform** is one of the latest Internet concepts and comprises one of the key elements of Web 2.0. The notion of the web-site or portal is replaced by a much more complex environment where the lines between the web-site and the software application are no longer distinct. There are two components.

The **web-application** performs tasks that are similar to those performed by a desktop application. The advantage- no software is downloaded to the client computer, yet, the user has an experience comparable to using a desktop application. With corporate IT restrictions that limit the kind of software that engineers are permitted to have on their desktop machines, the freedom provided by the web-application is quite exhilarating. Additionally, software updates are easy and all users have access to the latest tools and accessories as soon as they are deployed.

The **web-database** is the second element of the platform. Just as the application is liberated from the client desktop, so is the content. Important data of the enterprise, that has value to more than a single individual must not be stored on a client computer. Yet, this is more often than not, the way in which most enterprises store millions of dollars worth of data. Applications that are used for such storage are myriad, ranging from the ubiquitous Microsoft Excel to small databases. These data sources are almost always inaccessible to the rest of the enterprise except via the human gatekeeper who controls both the visibility as well as the access to the data. Critically, the data will eventually be lost either when the client forgets what he has on his computer, leaves, retires or his computer dies. See Figure 1 below

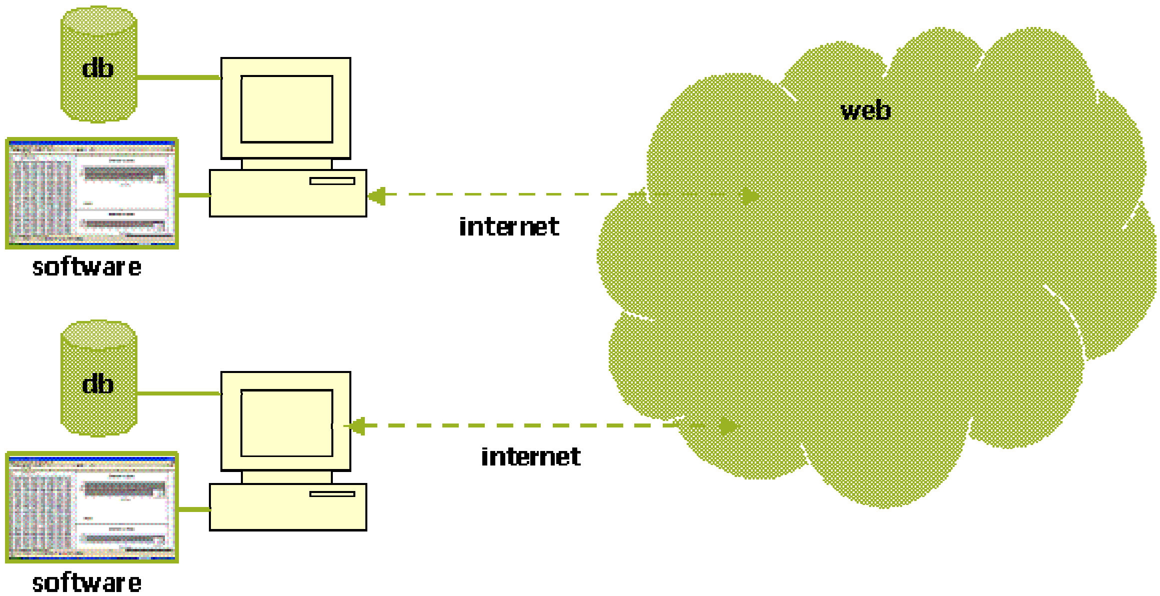

Figure 1. Conventional view where applications and data reside on client computers

Now, content management systems have been proposed as an alternative to the web-database. They offer some relief by moving the data files to a central repository. While excellent for documents, they are a poor choice for data-rich content for many reasons. Mining this data remains a problem because the contents of Excel and Word document files cannot be searched with ease. Reliance on keyword tags then remains the only way to identify the content of a data file. If these are not entered diligently by the content provider, then the data becomes useless to the enterprise. You have access without visibility.

The web-database presents the solution to both the problem of data accessibility as well as persistence. Data is no longer stored on the client computer but in a common repository under the control of the client (Figure 2). This presents the same level of security as before, but with two novel benefits: the enterprise knows about the existence of all its data and the data survives the client becoming an integral part of the intellectual property of the company.

The **web platform** is used to deploy a number of individual material databases belonging to different companies. Each database forms a common source for authorized employees of the company to locate and deploy material properties irrespective of their global location. The individual database owner can set and modify access privileges for the data in his database. These controls ensure that the data is properly used. Access controls can be highly restrictive or completely open. For example, a material supplier may place their common properties in the public domain as a marketing tool for all to access, to increase the visibility of their materials among designers. At the same time, they might keep their high value rate-dependent properties under lock and key, making it

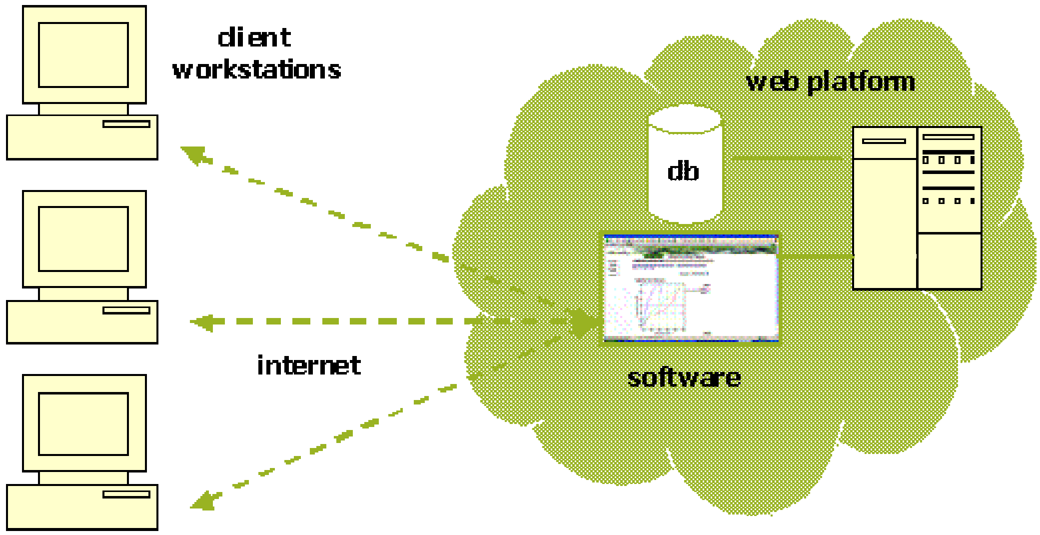

Figure 2 The web platform and its interaction with individual users

available only selectively to validated prospects. A maker of biomedical products, might keep all their data private, making it available only to authorized employees of their company. Now, these individuals would still have access to the public data of the materials supplier in addition to their own data. The web platform could also house "for fee" databases of companies that would like to sell properties, making access available only upon payment.

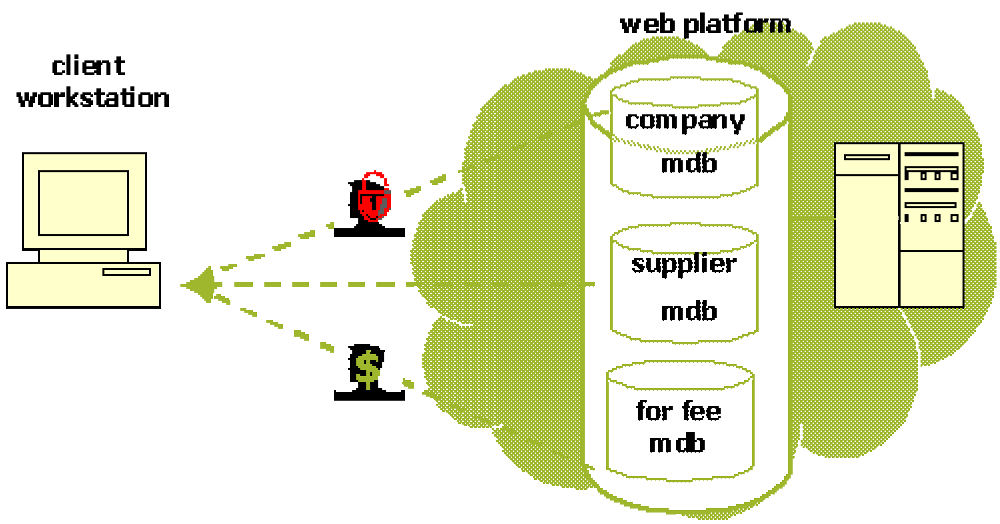

Figure 3 Different types of databases on the web platform

3: Web Platform Features

The web application can comprise a number of tools and features that make the content of the web-database useable. One can broadly categorise these as follows. Section 4 describes how material databases are deployed on the platform. Tools to locate content via vertical search engines (VSEs) are explained in Section 5. In Sections 6 and 7, we elaborate on data visualization and manipulation tools that allow the user to work with the content that they have located. Section 8 contains descriptions of Data Sharing and other communication tools that facilitate information exchange.

4: Ready-to-deploy Material Databases

The web platform is by design extensible in nature so that it can deploy the hundreds of kinds of properties that are measured in the world today. Extensibility permits the on-the-fly addition of new types of properties removing the most serious bottleneck in material database design, which is how to create a system that serves current as well as future unanticipated needs. Material databases hosted on the web-platform do not need to be designed and built prior to being populated with the data. This is a big cost and time saving because the only deployment effort comes from the transfer of data into the database.

5: Locating and Obtaining Access to Properties

Since it is customary in today's product development environment for companies to work in a collaborative manner, discovery tools are needed to permit platform users to locate data of interest that might exist within the material databases located on the platform. These might include personal databases as well as those of material suppliers and development partners.

VSEs are a powerful way to interrogate data to obtain highly pertinent search results. These engines differ completely from typical search engines found on the Internet today that force the user to apply human intelligence to determine whether the results they have found are pertinent. Because content is stored in a web-database, data can be tagged with a variety of vital information that can be used to identify a different of characteristics of the data; for example, the name and classification of the material, its source, what property, who tested it, when, to what norm, just to name a few. The VSE can now perform targeted searches against these tags, ensuring that the recovered content matches the criteria of the user exactly. This tool is critical for the repurposing of data for other applications. So, for example, it is possible to mine a vast repository of material data containing hundreds of types of properties to extract only data that is pertinent for an injection-molding simulation, or to find silicone materials for which hyper-elastic properties exist (Figure 4).

Figure 4 VSE search result for data relevant to ANSYS simulation

An important factor in the operation of VSEs that mine high value data collections is security. Access to such data is often tightly controlled. While there are data collections on the web database placed specifically for access to all users of the system, more often than not, data is sequestered, with access controlled by the company that owns the data. This prevents unauthorized use of the data. While this might prove to be frustrating to the casual browser of the system, the VSE provides two important mitigating benefits. First, it permits the casual user to find out if the data is indeed available. Second, a positive match allows the user to request access to the discovered data. Typically, access will be granted when the owner of a database recognizes the requestor as a collaborator in their development process. Figure 4 above shows the result of a VSE search where all the discovered data is private in nature. The web application would permit the user to create a ‘Request for Access’ to the owner of the data.

6: Data Visualization and Manipulation

A material data-intelligent web interface greatly enhances the ability of the analyst to assimilate and understand the material data they are using for important design decisions. Modern day material properties capture dependencies on a number of variables such as rate, time, temperature, pressure and the environment. Classic examples include high strain-rate tensile properties used in crash simulations, hyper-elastic properties of rubber and elastomers, rheology data, visco-elastic properties that capture the time dependency of materials, fatigue and creep, in addition to simple stress-strain curves.

Graphs are an excellent way to view complex material data. However, visualizing such complexity using simplistic tools such as Excel is frustrating, error-prone and time consuming. With a web application designed for the purpose, a click of the button presents all the possible dependencies existing in a dataset. These automated summarization tools provide a way to view dependencies such as how stress-strain curves vary with temperature or strain rate.

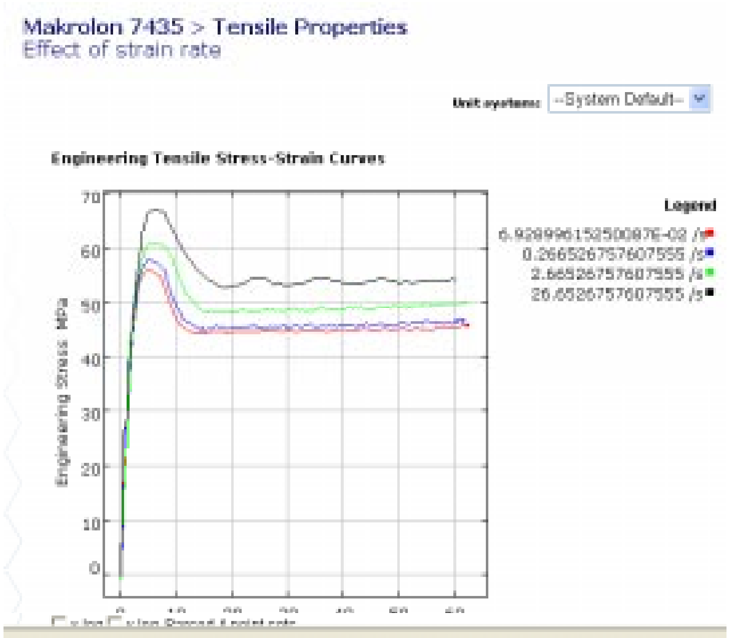

Figure 5 Visualizing auto-summarized data with the web application

Additional functionality that is commonly needed by the engineer include unit conversions, a common source of error, and simple derivative calculations such as the calculation of slopes, means and standard deviations. More complex tool-sets include regression and data transformation tools to fit data to equations and material models that are compatible with the user's needs.

Lastly, the presence of the pedigree information related to the data adds confidence regarding the suitability of the data for the purpose at hand.

7:   Tools for Material Card Creation

A critical component of material data is usability. Much too often, CAE codes require the data to be converted into forms that are different from the raw data. This process is intimidating for most CAE analysts. It is also error prone because of the lack of clear guidelines for the conversion of the data. The following simple example serves to illustrate the steps in such a conversion. The elastic-plastic material model is ubiquitous in the simulation of non-linear materials. Very commonly, stress strain data is expressed as a large number of datapoints in the engineering form with typical units of MPa and % strain. The model calibration is based on a true stress-strain curve that needs to be converted into an initial linear region, described by a modulus, and a series of stress v. plastic strain data pairs to describe the plasticity or hardening component. Many analysts in the US, for example would prefer to work in psi instead of MPa. First, the data needs to be converted from engineering to true and then to the right units. Then the linear portion of the curve is selected by visual inspection or other heuristics. The rest of the curve is then discretized into six to ten datapoints that describe the stress strain curve.

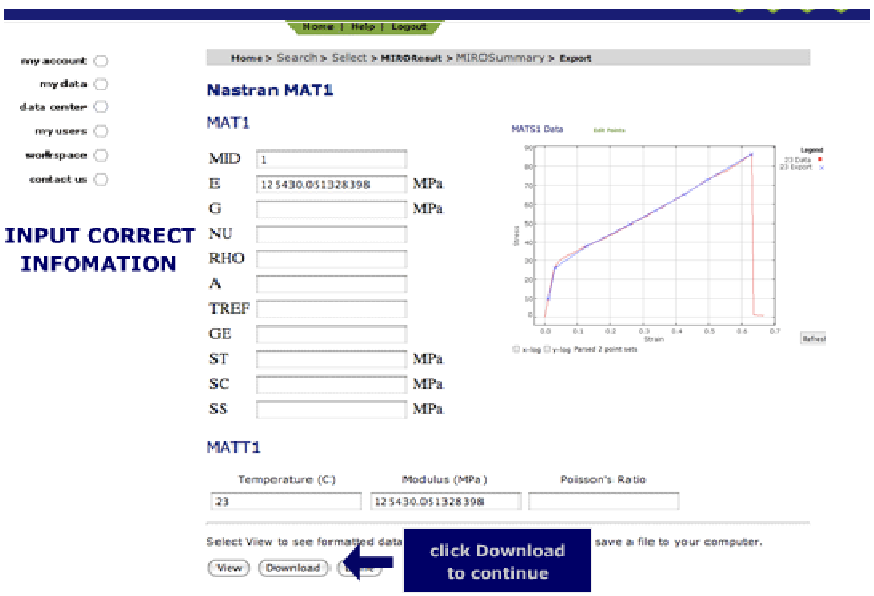

Figure 6 Web interface for the automated creation of NASTRAN MATS1 material card

With a material data-intelligent web application it is feasible to incorporate tools to perform these operations with simple interactive user interfaces to guide the analyst in the creation of their materials data cards. While the data conversion steps would be transparent, actions such as point selection are facilitated by the user interface. The analyst can then focus on exercising his skill without the distraction of the mundane conversion tasks or the writing of the complex material data card input files. Figure 6 illustrates such an interface. In a similar manner, more complex material model calibrations such as hyperelastic, temperature dependent or high strain-rate properties can be written.

8:   Aiding Collaboration and Information Exchange

While the web platform can easily serve the individual analyst as a personal material database, the true value of the platform comes to the fore in a collaborative environment. The ability to locate data across material databases provides a mechanism for analysts to share data both within and across collaborating enterprises. As stated earlier, a security framework is essential for collaboration because business logic controls who has assess to what data. For example, some data might be quite sensitive so that only certain persons can have access to it. Such data would be inaccessible by the VSEs so that there is no possibility of its presence being detected. The only way to transmit such data would be via Data Sharing. Sharing in the web-platform environment occurs when a peer sends a data link to another peer. The recipient can see the data only with the permission of the database owner. This form of data communications is more secure than conventional e-mail attachments because the data itself is not in circulation but is accessible only to persons to whom permission has been granted. The link, even if forwarded cannot be viewed by an unauthorized user. These steps greatly enhance data transmission security and thereby facilitate collaboration. Database owners monitor the usage of their data and can terminate access to their data by a recipient at any time. In contrast, data erroneously transmitted via e-mail attachments cannot be retrieved. Analogously, data that is held privately, requiring permission for access can be exposed by a peer-to-peer “Data Access Request“ to the database owner. Lastly, the value of openly accessible material databases is a substantial benefit of the platform. Typically, material suppliers would host such databases. Even with databases of this kind, suppliers can maintain control by opening their content for free access by their client companies while still requiring other platform users to request access for permission.

A substantial advantage of the Data Share is that information is presented to the recipient in a rich environment where the data can be viewed, analysed and post-processed within a material data-intelligent web interface. This is unlike the “material card in the e-mail attachment”, where it is completely unknown what data that card was based upon, its unit system, or its pedigree.

9: Conclusions

Material data are a much needed commodity for modern product development and CAE. A substantial quantity of valuable and useful data exists in the world today. However, it is inaccessible to most primarily because its existence is unknown. A web platform that permits the hosting of private material databases provides a collaborative environment for the selective and controlled sharing of high-value data. Properties are transmitted in a secure manner and can be viewed by all in a rich environment which permits data visualization, manipulation and download to third party applications.

10: References

1. Lobo H & Gandhi R "Enterprise-Wide Materials Data Management Ensures CAE Fidelity", NAFEMS 2005 Proceedings, (2005).