The Geospatial Managed Environment

Oscar CUSTERS, The Netherlands

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SUMMARY

Bentley has been involved in the geospatial world since the early days. Especially in the data creation stage MicroStation as graphical platform has always played – indeed: is still playing -- an important role. Thousands of organizations across the globe use Bentley products to create, manage and publish CAD en GIS data. For the last couple of years, Bentley Geospatial has been working on evolving its products and solution portfolio from workstation oriented products to an enterprise-wide architecture called the Geospatial Managed Environment. The Geospatial Managed Environment is Bentley's response to an ever growing demand for data accuracy and quality. It is a multi-tier architecture combining flexibility on the Desktop – using XML Feature Modeling– with a server-driven controlled environment – ProjectWise – connected to enterprise data stores like Oracle Spatial databases.

Adding Oracle connectivity was crucial milestone for Bentley in designing the managed environment architecture. For many, Oracle Spatial is the de facto standard for enterprise geospatial data stores. The Geospatial Managed Environment now offers a multi-user, scalable gateway to Oracle with true semantic interoperability. This way, Bentley positions itself as the natural partner for data accuracy and quality within Oracle Spatial data stores. By avoiding the pitfall of adding its own idiosyncratic ways of dealing with data, the solution instead concentrates on faithfully reproducing what is in the data store. In short: it plays by Oracle's rules, without cheating. Delivering true Oracle Bentley interoperability is the result of years of cumulative investment. As one of the first to identify the potential of the Oracle platform, Bentley is again breaking new grounds by evolving from a two-tier to a multi-tier architecture. It believes this to be a necessary step to tackle current and future demands in the Geospatial world.

Today, the use of maps or map data is ubiquitous; the use of navigation systems in cars is a good example. The introduction of a phenomenon like Google Earth is another high profile development that recently caught the attention of many. As a result the demand for up-to-date, high-quality geospatial data has never been bigger. This forces the owners of data to further rationalize the data maintenance cycle, to invest in an environment that is capable of increasing productivity. With the Geospatial Managed Environment Bentley is taking the data maintenance cycle seriously and bringing it to the level it belongs: the enterprise. By offering true ArcGIS, Oracle and SAP interoperability, Bentley acknowledges the need for Geospatial

data both inside and outside the traditional GIS arena. With its encompassing software architecture it delivers the tools to make it happen.

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1. INTRODUCTION

Often, the Geospatial (previously: GIS) world is treated as one homogenous entity. In reality, it is more like a diverse collection of different activities in a wide range of markets with only one element in common: dependency on geospatial data. Nowadays, the traditionally non-Geospatial world is quickly adapting to the use of map and map data. To quench the thirst for map data, the geospatial world faces on of its biggest challenges yet: to overcome it's proprietary, workstation-centric approach and start dealing with Geospatial on an enterprise, interoperable level.

1.2 Use / Analysis versus Maintenance

From a functional perspective, the Geospatial world has always been divided in – roughly – two camps: those who put the emphasis on the use/analysis of geospatial data, and those who focus on maintaining the life cycle of geospatial data. Typically, the definition of Geospatial is correlates with the main emphasis on either the former or the latter.

In the last few years, emphasis has mainly been on expanding the use of geospatial(ly related) data and less on its maintenance life cycle. This is a two-edged sword. On the positive side, the widespread use of Geospatial data puts the industry in the spotlight; the use of maps in car navigation software and on the internet – see the recent Google Earth phenomenon – now seems ubiquitous. At the same time, however, a significant number of organizations are facing data accuracy and data quality issues.

Data accuracy and quality is directly related to data maintenance. Neglecting data maintenance is a fundamental threat to what you can do with data. Inaccurate or out-dated data can seriously reduce the impact of data analysis. Or – even worse – has the risk of drawing the wrong conclusions. To overcome this issue, the balance should possibly shift towards more emphasis on the data maintenance cycle.

2. GEOSPATIAL AND BENTLEY

Bentley has been involved in the geospatial world since the early days. Especially in the data creation stage MicroStation as graphical platform has always played – indeed: is still playing -- an important role. Thousands of organizations across the globe use Bentley products to create, manage and publish CAD en GIS data.

For the last couple of years, Bentley Geospatial has been working on evolving its products and solution portfolio from workstation oriented products to an enterprise-wide architecture called the Geospatial Managed Environment. The Geospatial Managed Environment is

Bentley's response to an ever growing demand for data accuracy and quality. It is a multi-tier architecture combining flexibility on the Desktop – using XML Feature Modeling– with a server-driven controlled environment – ProjectWise – connected to enterprise data stores like Oracle Spatial databases.

2.1 Geospatial Trends

The Geospatial Managed Environment is Bentley's answer to how the Geospatial market place is evolving.

Currently, Bentley identifies five important trends in Geospatial:

1. Higher accuracy – a lot of the data out there does not have the accuracy we need today. Often, Geospatial data is based on inaccurate digital and analogue data sources. And – sadly – most Geospatial data is 2d only, thus neglecting a (potentially) very important dimension for many. With a trend towards higher data accuracy and 3D, data maintenance has a lot of catching up to do.
2. More "GIS" in maintenance – topology, linear referencing, maintaining objects, object relations; the days of simply drawing points, lines and polygons are over. What is needed now is modeling of objects that more realistically represent the real world. Real objects increase the usability of the data at hand, for example to meet the demand for increasingly sophisticated geospatial analysis.
3. More control over maintenance – workflow management auditing, logging, integrating documents are essential in many organizations, but often the tools are missing to streamline data maintenance processes. Significant gains in productivity can be expected if the data maintenance process is put under some form of software-guided control.
4. Interdisciplinary operability – integrating with other engineering disciplines. Expanding GIS to Geospatial is only the first step. Next, boundaries with other disciplines will (have to) go. Data sharing amongst for example Geospatial and Civil disciplines has the potential to increase dramatically in the coming period. Geospatial is not a field that stands on its own; it has overlap with many other engineering disciplines. Data sharing will be mutually beneficial.
5. Enterprise data stores – many organizations are in the middle of a migration process of their data into enterprise data stores. A more centralized and generic way of storing Geospatial data, allows access that goes even beyond the scope of interdisciplinary operability; it opens a whole new world of "mix and match" between Geospatial and other data sources.

2.2 Bentley's Response

How does Bentley face the challenges related to these five trends?

1. Higher accuracy – over the years MicroStation has constantly improved itself to be one of the best high precision, true 3d platforms in the industry. Ironically, many Geospatial users have used the platform to capture data in 2d only. Even though, the 3d capabilities have been available for many years now. In addition to the capabilities of the base platform, the

Geospatial vertical applications offers over 4000 coordinate systems and an extended set of topology-driven and other Geospatial tools – all developed to work in 2d and 3d setups.

2. More "GIS" in maintenance – the new XML-based Feature Modeling paradigm is a solid foundation to actively respond to the increasing demands for more sophistication in the data maintenance life cycle. It allows for the definition of geographical objects that go beyond the limitation of simple features. Objects can be constructed of multiple features, with the possibility to add specific behavior both within the feature itself and in relation to other features. This modeling paradigm is the starting point for all clients in the Geospatial Managed Environment.

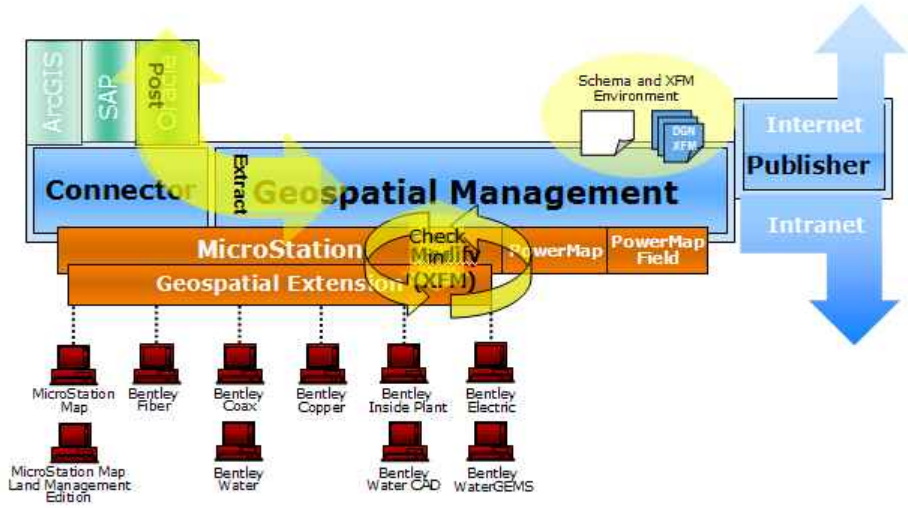
3. More control over maintenance – since a number of years Bentley has a second platform product, this time for use on a server level – ProjectWise – which was specifically for content created, viewed and used in geospatial workflows. It effectively manages the complex relationship between shared design and map data, the information they contain, and any associated content. It regulates access and synchronizes data between (potentially) large numbers of sites.

4. Interdisciplinary operability – besides Geospatial, Bentley distinguishes three other engineering disciplines: Building, Civil, and Plant. For each discipline a wide range of products and solutions exists. All of Bentley's vertical activities share the same foundation – MicroStation and ProjectWise – thus making interdisciplinary operability a reality. Data created in any of the four engineering disciplines can be (re)used in any of the others; data exchange between disciplines is easily achieved.

5. Enterprise data stores – Through its connector strategy, Bentley interfaces with the two of the most important enterprise data store platforms in the market today: ArcGIS/ArcSDE and Oracle Spatial. By offering an enterprise-scale solution, Bentley is positioning itself as the ideal data maintenance environment for Geospatial data stores. As a rich environment for the data maintenance life cycle, connecting to it is a very interesting proposition for platforms that focus more on data analysis – ArcGIS/ArcSDE – or platforms that lack the tools for data maintenance – Oracle spatial.

3. THE GEOSPATIAL MANAGED ENVIRONMENT

So what is the Geospatial Managed Environment? In short, it is the sum of Bentley's response to the five trends discussed before. It is one, comprehensive architecture that integrates the Bentley Geospatial product portfolio with enterprise data stores. Its design reflects one very important goal: to addresses the whole life cycle of geospatial data management, including integration of the storage of geospatial data in enterprise data stores.



The Bentley Geospatial Managed Environment

The Geospatial Managed Environment Contains a number of important principles and functionalities. Top down, these are:

1. An Enterprise Data store – while still supporting the storage and maintenance of files, the Geospatial Managed environment gravitates towards storing all geospatial and associated attribute data is in an open system, that is easier accessible outside the engineering realm. A data store could be the Enterprise's Asset Management System or supporting Operational and Financial core processes. Prime example: ArcGIS/ArcSDE and Oracle Spatial databases. Other example: SAP or CRM systems.
2. ProjectWise – the nerve center of the Geospatial Managed environment, providing a large number of functions to allow for what Bentley calls "collaborative engineering". ProjectWise in itself is built on database technology, such as Oracle. The roles and capabilities of ProjectWise are, in general:

A. Long and short term transactions to the Enterprise Data store – ProjectWise uses Connectors to these data stores; for specific applications, also transaction messaging is used.
B. Managing of outstanding transactions by metadata – transactions are typically being processed by MicroStation-based and other environments; ProjectWise drives this process and keeps track of the changes in content and its metadata.
C. Managing of stand-alone Geospatial content – not all data will be stored in the enterprise data store, this is typically limited to an organization's core assets. For many purposes data will be stored in files, e.g. for departmental solutions data in files can be managed by ProjectWise "as is", without the requirement to migrate them to the enterprise level.
D. Managing of XFM Schema's – in the Geospatial Managed Environment the XML-based Feature Modeling environment contains the semantic model of the data it refers to. ProjectWise hosts these schemas and links them to either a specific use or a specific user. They faithfully reproduce the data model in the Enterprise Data stores or the data model used in the geospatial files used on e.g. a departmental level.

E. Providing Geospatial search tools on stored content – all data, geospatial and administrative, in databases or files controlled by ProjectWise can be viewed and searched with a geospatial interface, called the Geospatial Extension. Not only does this provide an intuitive interface on data, the powerful search option allows for map based searches for any project related content. You can "spatially Google" the data stored in the ProjectWise repository.

F. Managing all project-related non-geospatial content – ProjectWise does not restrict itself to geospatial content. Besides maps in databases or files, all relevant project data – documents, contracts – can be stored. In other words: ProjectWise is capable of serving as a comprehensive Document management System and stores Excel, Word or the like.

G. Component based indexing – ProjectWise goes one step further than controlling the storage of files and data in Enterprise Data stores, it is also capable of indexing individual entities – components – within files or data stores. Functionality like searches, workflows are available on the component level as well.

H. Web and desktop interfaces – ProjectWise can be interfaced using either a desktop client or a web client. In terms of web development, Bentley is rapidly integrating ProjectWise components with Microsoft's Sharepoint.

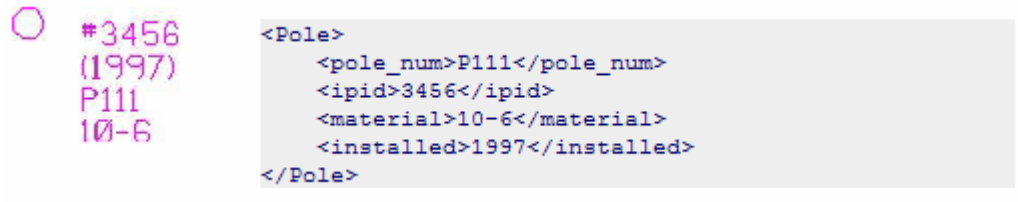
The ProjectWise environment

3. MicroStation GeoGraphics with XFM – a rich and accurate editing environment, including the possibility to define and work with geographic objects instead of atomic geometries. As a base platform, MicroStation already offers one of the richest editing toolsets in the industry. A constantly evolving product over many years, it fully responds to the industry's demands for higher accuracy. In addition to accuracy, the demand to get more "GIS" in maintenance needs to be fulfilled. For, this the concept of XML-based Feature Modeling was introduced.

3.1 XML-based Feature Modeling (XFM)

The MicroStation GeoGraphics XFM (XML-based Feature Modeling) engine provides an extensible metadata driven framework to define feature properties, symbology, annotation rules and behaviors. An XFM feature may contain geometry, properties and sub-features. All feature components have linkages that define their relationship to each other.

For example, a power pole might be a feature that a utility company wants to maintain. The properties of the power pole may be type, material, pole number, id, and date installed. The figure below shows the graphic representation of the feature on the left and the XML property data on the right.



Graphic representation and property data of an XFM geographic object

In this case, the pole is the primary (or: root) feature and that has been named Pole and the annotation is defined as a sub-feature. Three elements would be added to the Geospatial Managed Environment to define this pole feature – the pole graphical object, the annotation text, and the XML fragment element. Within the XFM paradigm, these individual objects are treated as one.

XFM was designed to bring productivity on the client for maintaining Geospatial to a new level. It offers a number of advantages over traditional CAD en GIS editing environments. Feature geometries and attributes are contained as one, either within a single document (design file) or inside an enterprise database. Data is extracted and posted between those two sources. Features can be copied, moved, deleted; user operations can be undone and/or redone without fear of corrupting links.

The XFM engine is driven by XML metadata – which generated and maintained in a separate environment (the Bentley GeoSpatial Administrator). This metadata framework is used to drive that display and behavior of the geographic on the client, including property based symbology – for dynamic thematic display – property based symbology – as shown in the pole example above, the ability to define features for different plot scales, provide sophisticated placement and modification methods for manipulating geographic objects, etc. The whole XFM concept designed to provide the flexibility and depth to model/maintain Geospatial feature instances found in enterprise data stores.

4. THE CONNECTOR STRATEGY

Combining ProjectWise and a Bentley client will ensure interdisciplinary operability. For interoperability on an enterprise scale connectivity with large data stores is essential. Especially when responding to a strong trend within the geospatial industry to migrate data to centralized spatial database.

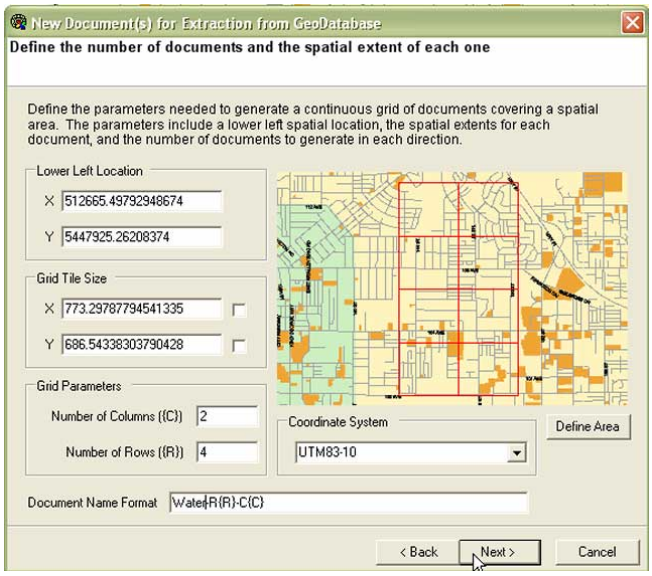
With its connector strategy Bentley provides a gateway between the geospatial (or even: multidisciplinary engineering) world and the enterprise. Bentley has gained a lot of experience when it comes to interfacing with other systems, both on a product and a services level. For the connectors, its decision was to bring interoperability to the only appropriate level – the enterprise. Based on the important experience of previous development efforts, three design principles where defined:

- True semantic interoperability – by trying to understand how the other platform works and adjust accordingly. Don't superimpose your own idiosyncratic ways of dealing with data on the data store you want to connect to. XFM gives Bentley Geospatial clients the flexibility to adapt and adjust.
- Multi-user access – being aware that connecting to an enterprise data store means more access complexity. So develop a solution that is allows for multiple (long) transactions to be handled at the same time. Using an enterprise data store requires a sophisticated interface for locking data, replacing the simple file-locking mechanism used when data is stored in files.
- Scalability – understanding that using an enterprise data store will broaden the scope and scale of the use of geospatial data. Different departments might start to work on the same data store; people in more physically separated locations will want to access it. A system will need to accommodate this.

Defining fundamental design principles for Bentley's connectors was not a trivial exercise; they were used as a guideline to avoid one of the biggest pitfalls around: the creation of a 'just-another-data-format' solution, i.e. the development of an expensive storage option to the DGN file. With its connector strategy, Bentley avoids this pitfall and offers a true gateway to the industry's leading solutions for enterprise data storage.

4.1 ArcGIS

To accommodate the ArcGIS user who likes to optimize the maintenance of data stored in Geodatabase(s), Bentley offers the ProjectWise Connector for ArcGIS software. The connector is a gateway between ESRI's ArcGIS platform and the Bentley Geospatial Managed environment. By establishing a link through ArcSDE a connection is being made to the data stored in ArcGIS data stores. Based on the principle of extraction, data is copied out – and locked, using ArcGIS' own transaction manager – and maintained in the Managed Environment. Using the flexibility of the XFM framework, the semantics of the data is guaranteed. After modification data is posted back to the Geodatabase.



Extracting of data from a Geodatabase

The deployment of the ArcGIS Connector makes it possible to rationalize the Geospatial data life cycle management using the Bentley environment. It allows the ArcGIS environment to concentrate on providing analytical depth by dispatching data maintenance to the Geospatial Managed Environment. By offering a connection between with ArcGIS, Bentley has a very interesting proposal for existing ESRI users. It offers a high-precision data maintenance environment often needed to keep its geospatial data up to date.

4.2 Oracle

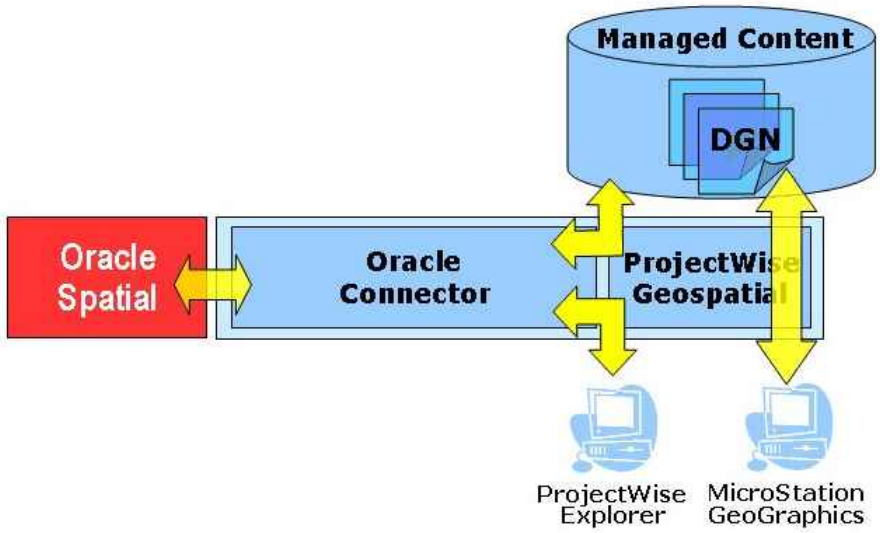
For a number of years, Oracle has been positioning itself as the enterprise data store for geospatial data. Oracle Spatial development started halfway through the nineties and has been progressing steadily since. The current release – Oracle 10*g* – has added yet again number of features to the product, including topology.

Since the early days of Oracle Spatial, Bentley has been on Oracle's tail. Initially focusing on a two-tier architecture, with the connector strategy it raises the bar to the next level: a multi-tier architecture.
With its connector for Oracle, Bentley positions itself as one of the best alternatives in the market for maintaining Geospatial data in Oracle databases:

- It faithfully extracts data without information loss, and posts back modifications. It supports all of Oracle Spatial native data types – a superset of the Open Geospatial Consortium's *Simple Feature Specification* – without superimposing its own standards or (technical) metadata. The Oracle Spatial topology model – introduced with 10*g* – is also supported.
- It leverages the power of Oracle's Workspace Manager, both in version management and conflict resolution. Thus enabling the implementation of truly controlled multi-user maintenance operations.

- It is a scalable solution, which can be configured to meet the requirements for tens to hundreds of users. Extracting of data can be configured according to the number of servers.

All process take place in a controlled environment, with the options to include the extract, modify and post sequences in workflows. In short, the Bentley ProjectWise Connector for Oracle (also referred to as the Oracle Connector) is server software which provides a variety of services for the exchange of Geospatial content between the Oracle database and DGN content managed by ProjectWise.



The Oracle Connector architecture

ProjectWise Explorer is the client application used to order extraction or post operations to the Oracle server. The Connector then executes the requests and controls the exchange between the Oracle database and the managed DGN files. MicroStation GeoGraphics with XFM is used to view, capture or modify the content of the managed DGN files. By using the Connector to transfer geospatial content between the Oracle Spatial database and the Bentley Geospatial Managed Environment, the rich Bentley editing environment can be leveraged.

5. CONCLUSION

Today, the use of maps or map data is ubiquitous. This forces the owners of data to further rationalize the data maintenance cycle, to invest in an environment that is capable of increasing productivity. With the Geospatial Managed Environment Bentley is taking the data maintenance cycle seriously and bringing it to the level it belongs: the enterprise. By offering true ArcGIS, Oracle and SAP interoperability, Bentley acknowledges the need for Geospatial data both inside and outside the traditional GIS arena. With its encompassing software architecture it delivers the tools to make it happen.

CONTACTS

Drs. Oscar Custers
Director
Geospatial
Wegalaan 2
2132JC Hoofddorp
Netherlands
Tel. + 31 653232703
Fax: + 31 235560565
Email: Oscar.Custers@Bentley.com