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Leveraging SDE 9.2 Geodatabase Replication
for Integrating As-Built Data

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ABSTRACT

At release 9.2 of SDE, there are significant enhancements in the tools for generating replicas within and between geodatabases. This presentation shows how these enhancements have directly benefited the water-facility as-built processes within the Southern Nevada Water Authority. From initial transfer of information from CAD designs into GIS, through the stages of field data collection during and post-construction, to final as-built facilities storage, a consistent data delivery approach has been applied to ensure consistent, reliable, secure and cost-effective GIS data maintenance. This unifying process relies on a 'best-of-breeds' approach wherein differing tools are utilized for their strengths in a heterogeneous computing environment. The process relies heavily on the creation and management of Geodatabase replicas for the deliver of data to and from spatial data management steps. The results are shorter data editing cycles and more accurate edits as compared to versioned edits within desktop GIS.

INTRODUCTION

The Southern Nevada Water Authority (SNWA) is a cooperative agency formed in 1991 to address Southern Nevada's unique water needs on a regional basis. The agency is charged with managing the region's water resources and providing for the present and future water needs of the Las Vegas Valley area residents and businesses. SNWA is governed by a seven-member agency comprised of representatives from each of its member organizations. The seven member agencies providing water and/or wastewater services to Southern Nevada include: Big Bend Water District, Boulder City, Clark County Water Reclamation District, City of Henderson, City of Las Vegas, the Las Vegas Valley Water District and the City of North Las Vegas.

Each of these member agencies is responsible for the operational aspects of the existing retail water distribution system within their jurisdiction, as well as for the planning, design, and construction of future improvements to those systems. In a similar way, organizational components within SNWA are responsible for the planning, design, construction, maintenance and operations lifecycles of various water facilities which comprise the wholesale water delivery system for Southern Nevada; these components fall either within the SNWA Engineering or Maintenance and Operations departments.

Engineering information plays an important role in lifecycle activities of water facilities within SNWA. Agenda maps, engineering drawings, specifications, operations manuals, Global Positioning System (GPS) observations, maintenance work orders and Geographic Information System (GIS) data are all examples of information that is critical to business activities at one point or another during the lifetime of a water facility asset. This information is housed in several key systems. Each system is accessible by SNWA staff performing tasks as required to meet the current and future water demands of Southern Nevada.

However as the variety of different types of engineering information has increased to keep pace with innovative trends within the water industry, the number of systems capturing and maintaining this information has also increased. This increase in the number of systems has brought an increase in procedural complexity for SNWA staff needing to utilize new systems and gain access to information. Increasing system complexity resulted in strategic re-positioning of SNWA's GIS tools to be a more centralized point-of-access into other systems. Within the SNWA Engineering, the Knowledge and Technology Management (KTM) division is responsible for addressing the production, storage and accessibility of engineering information such as drawings, maps, GIS data, as well as responding to departmental requests for work process technology solutions. The KTM division's responsibilities include the technical details of making of SNWA GIS a point of access into other systems.

GIS AS AN ACCESS-POINT

Because of the organizational overlap between SNWA a member agency, the Las Vegas Valley Water District (LVVWD), the two agencies share GIS resources such as support staff, servers and file-systems, database instances and software licenses. The combined SNWA/LVVWD GIS system operates on ESRI ArcSDE 9.2 running on Unix/Solaris

servers and accessing Oracle 10g database instances. This combined enterprise GIS also involves challenges on both the technical and inter-disciplinary level. Examples of the challenges that come with enterprise-level GIS implementation are: cross-departmental ownership/authorship of GIS data layers, access permissions across departmental lines, shared responsibility of domain management, and coordination of ArcSDE compress schedule. Each of these obstacles affects the continued success of enterprise GIS within SNWA/LVVWD.

For SNWA Engineering's KTM division, the above challenges have directly impacted the success of GIS as an access-point into other knowledge systems. A general design philosophy was adopted early in the GIS re-development effort which has worked to overcome some these obstacles, and is expressed in the GIS Credo:

"Don't store it, if it is already stored somewhere else."

In addition, the application of a consistent design consideration has been used in implementing each GIS access-point to the various engineering and operations systems, that is

"Identify a foreign key from the accessed system, bring it into GIS, then maintain keys."

Each detailed review of the system to be accessed typically reveals that there already exists a key attribute within GIS that identifies the feature in both systems; that common attribute takes on the role of the foreign key into the other system. The UML examples in Figure 1 show GIS layers relating by keys into the knowledge systems they serve as access-points for.

Figure 1: UML Examples Relating GIS Layers to Other Knowledge Systems
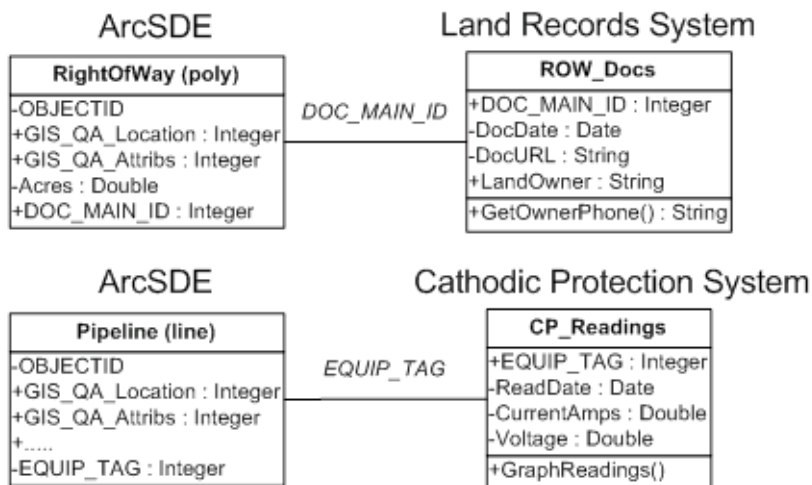
Notice that in the design of each GIS layer, the majority of information content remains in the "other" system while a single attribute is maintained within of the GIS layer. This type of GIS layer design makes appropriate use of existing knowledge systems as well as positions GIS query and display tools as central to a number of systems, perhaps not otherwise connected. An example benefit of this approach allows two disparate systems (a Land Records system and a Pipeline Corrosion Protection system) to be related to each other by GIS features (an easement polygon and a pipeline feature) and their overlapping topology (area overlaps line.) This scenario satisfies an operations business need of contacting the land owner before a routine monthly corrosion protection maintenance task is performed at a certain facility location, depicted graphically in Figure 2, below.

Figure 2: Scenario where access-systems traverse through GIS
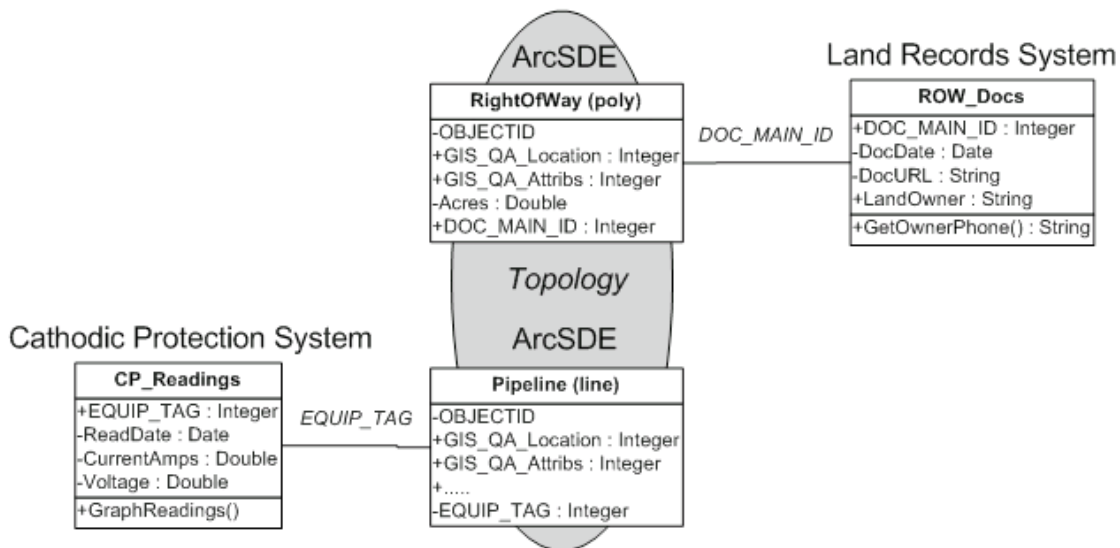
Scenario: Get the Land Owner's phone number before performing routine maintenance on a corrosion protection feature.

Note that GIS layers are constantly evaluated to identify enhancements which will meet new or changing demands for accessing disparate systems. Other departments frequently mandate and manage the data structures of these other systems. With ever-changing demands and little input into the structure of other systems, this raises the question of "What is the best way to maintain the data within the set of GIS layers to provide the requested system connectivity?"

Maintaining Enterprise GIS Layers
    The SNWA GIS is comprised of a number of layers that represent the water, electric, and telecommunications facilities making up the wholesale water delivery system. All of the SNWA layers are maintained using Spatial Data Objects (SDO) Oracle's spatial storage, and accessed using both ArcSDE and SQL-Plus. Because various business groups are the custodians of the actual devices and features, GIS layers which represent those features are maintained in different database schema.

Not all GIS layers represent physical devices; some of the layers in SNWA GIS represent the location where processes occur, such as an "inspection." The KTM division has been the custodian of these process-specific locations and resulting GIS layers.

Database roles are used extensively to manage the permissions that govern access to the GIS layers; a single database role is maintained to allow update permissions across all of the GIS layers. The staff within the KTM division Engineering are all members of this important database role. Table 1 shows the variety of physical objects represented within SNWA GIS as well as the custodian business group, resulting GIS layer, and database roles for access and update.

Table 1: Physical/Logical Devices and Resulting GIS Layers

Device	Custodian Business Unit	GIS Layer	Database Roles	
			Access	Update
Rights-of-Way	Land Records	ROW	SDE_VIEWER	KTM_EDITOR
Water Pipes	Maintenance/Operations	PIPELINE	EOS	KTM_EDITOR
Water Valves	Maintenance/Operations	VALVE	EOS	KTM_EDITOR
Enclosed Spaces	Env. Health / Safety	ENCLOSURE	SDE_VIEWER	KTM_EDITOR
Fiber Optic Cables	Maintenance/Operations	SEGMENT	COMM_VIEWER	KTM_EDITOR
Fiber Optic Pullboxes	Engineering – Design	PULLPOINT	COMM_VIEWER	KTM_EDITOR
Power Lines	Energy Mgmt.	POWERLINE	SDE_VIEWER	KTM_EDITOR
Reservoirs	Engineering – Design	RES	SDE_VIEWER	KTM_EDITOR
Pumping Stations	Engineering – Design	PST	SDE_VIEWER	KTM_EDITOR
Flow Control Stations	Engineering – Design	ROFC	SDE_VIEWER	KTM_EDITOR
Corrosion Protection	Maintenance/Operations	CPTS_XXX	EOS	KTM_EDITOR
Inspections	Engineering – KTM	INSPECTION	ENGSDE_VIEWER	KTM_EDITOR

In previous releases of GIS software dating back to ArcInfo, the data maintenance process was both very single-user and serialized. Even today, non-enterprise users of GIS maintain Shapefile (or Personal Geodatabase) layers in much the same way.
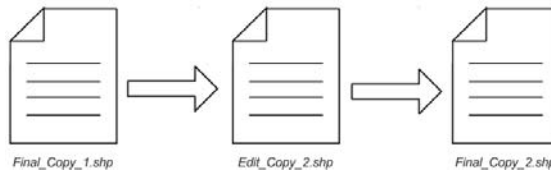
Beginning with ArcGIS Desktop 8 and ArcSDE version 2, SNWA migrated GIS layers to a multi-user, versioned editing model. In this model, data edits occur across multiple GIS layers at the same time. For SNWA GIS, this means user-specific edit versions receive the edits, get "reconciled" with parent versions, and edits get pushed up through the version tree into the Default version via the "post" function.
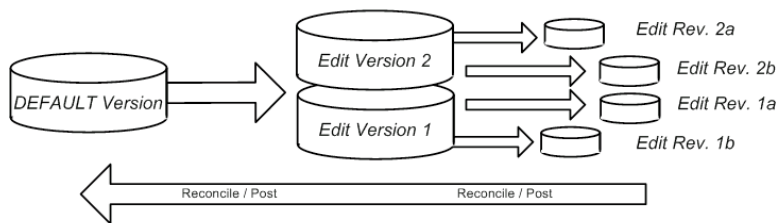
The evolution from serialized edits to enterprise-versioned edits has been extended by ESRI in SDE 9.2 to include complete GIS data replication between geodatabases. Because this replication process can be controlled to move data between parent and child replica databases in either one- or two-directions, the KTM division of SNWA is carefully considering which type of replica model to employ for each case of data maintenance activity. Table 2 identifies work-process activities, resulting GIS layer impacts, and the selected "best-suited" type of replica.

Table 2: Selection of Replica Type Based on Work Process

Work-Process	GIS Layer Impacts	Replica Type
Field data collection of material properties during post-construction asbuilting of facilities.	Read most current layers Edit selected features Returns edits to FACILITIES layer(s)	Two-Way *"Revisoning"*
Collecting corrosion protection electronic readings along a pipeline at specific locations and time intervals	Contribute new data to READINGS layer	Check-out (child to parent) *"Contributing"*
Navigate to locations adjacent to major facilities; evaluate the impacts of future capital improvements.	Read most current layers	One-Way (parent to child) *"Subscribing"*

An overall picture of the SNWA GIS layer maintenance activities is represented as a composite of these different replica types all simultaneously interacting with enterprise ArcSDE.
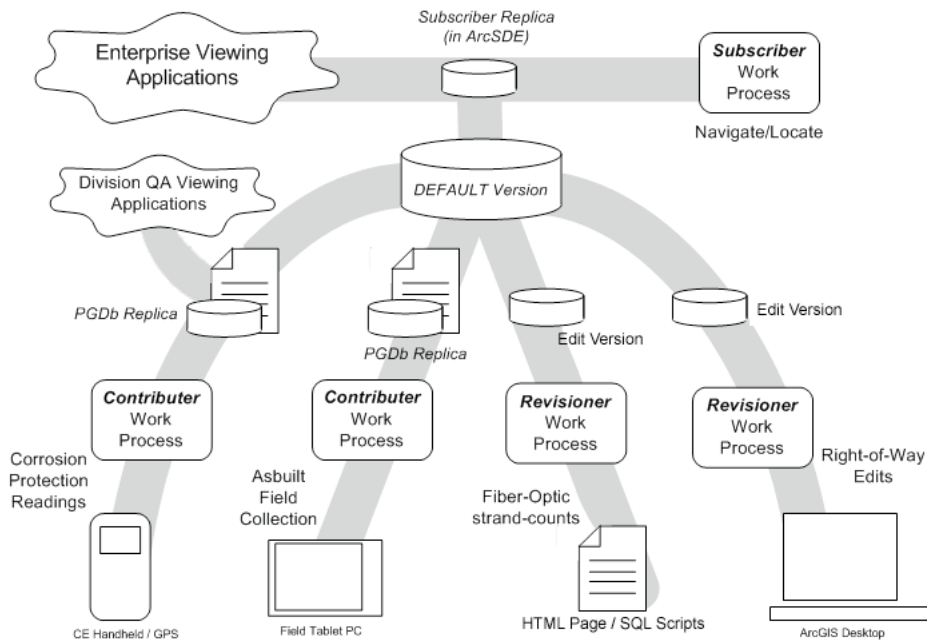
Practical Examples

The role of the KTM division in support of SNWA business processes is both a GIS data maintainer and GIS data collector. This dual role is most obvious in the example of post-construction field data collection activities. A multi-year effort is underway to visit, field-verify, and document the material and functional properties of a large portion of the wholesale water delivery system because the oldest portion of these facilities were purchased by SNWA after being constructed decades earlier by federal agencies. As a result of poor documentation and the construction processes at the time, not much is documented or known about the constructed state of these facilities. The KTM division is systematically growing the knowledge of these facilities through this field data collection effort.

To increase efficiencies during this programmatic collection effort, KTM has deployed a mobile GIS solution from TC Technology called Go! Sync Mapbook. This software solution is deployed on Panasonic Toughbook 19 tablet PCs, equipped with broadband cellular modems and consumer-grade GPS receivers. Although a number of alternative tools were evaluated including resource-grade GPS receivers coupled with ESRI's ArcPad, the mobile GIS solution on tablet PCs was selected for its overall robustness, connectivity, and flexibility.

Go! Sync Mapbook is deployed in both a server/office component, and any number of mobile clients; the server software is responsible for extracting the enterprise GIS data, packaging it for mobile client use, tracking which clients have synchronized with the server, and finally returning updates from the field to the enterprise. To maximize the effectiveness of GIS compatibility, the Go! Sync product uses an ArcGIS MXD map document to deliver standardized layers with symbology and annotation to the field clients. While deployed in the field KTM staff use GO! Sync Mapbook client to search for features within the local replica database, use GPS to navigate to the features, and populate forms for recording field information about those features. Below is a screenshot of SNWA GIS deployed on the Go! Sync Mapbook client.
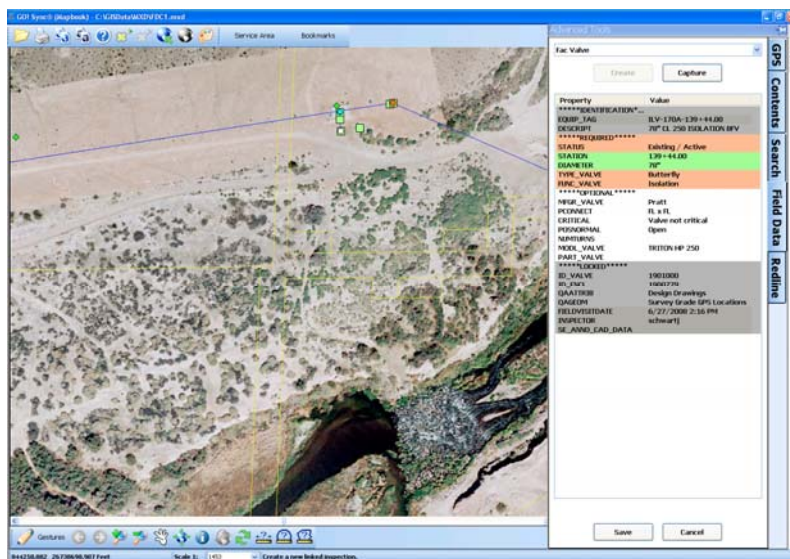
By using Go! Sync Mapbook in the field, KTM staff can locate facilities and record properties such as size, manufacturer and model numbers while they are in sight of the facility. Once a set of facilities are captured, the KTM staff return to the office and synchronize their collection data with the GO! Sync server. This field data progresses through a quality-assurance step before being synchronized with the Default version within ArcSDE.

The server-side connectivity between Go! Sync and SNWA GIS enterprise ArcSDE currently follows the "check-out" or "Contributor" replica model. A database connection within ArcCatalog is created which points to a specific check-out replica from ArcSDE. This connection file is saved to the file system, and then it is copied to the Go! Sync server. Go! Sync uses this connection for all interaction with the enterprise ArcSDE including data extraction and return data loading.

Another example of business process support based on GIS data maintenance is the collection and analysis of pipeline corrosion protection electronic readings. The SNWA corrosion protection system is an impressed-current system where DC current is applied so that alkali soil does not corrodes the water delivery pipeline. Routine monitoring of electronic readings at cathodic protection test stations is required to verify the proper levels of protection. The readings are performed in the field by qualified staff using volt meters and recorded into Trimble Geo-XT resource-grade GPS receivers running Trimble TerraSync software. In this manner, the GPS serves as a data recording device, and captures the locations where the readings took place.

Once SNWA Operations staff completes a set of readings, the GPS receiver is returned to the operations facility and docked. Microsoft ActiveSync software moves files from the receiver to the desktop PC, and the readings files are then moved to standard program folders on the organization network. Once the files are present on the network, the operations staff sends word to KTM that readings are ready for procession.

To process the readings, a geo-processing model python script, running inside ArcCatalog, identifies the impacted test stations by proximity to the GPS locations. Then the model merges the incoming readings for that station with previous readings. The geo-process runs against a check-out replica which in turn feeds a departmental QA viewing application. Once the results are validated in the replica, the readings are posted to the enterprise ArcSDE and the operations staff are notified of the process completion.

The Problem with Replicas

Currently, ArcSDE replicas of the type "check-out" rely on the creation of a version in the parent ArcSDE. Further, versioned layers used in replicas may not have been created with the "post to base table" checkbox enabled. All these details mean that, unfortunately for the replica user, their data is tied to A (adds) and D (deletes) tables within the parent ArcSDE instance. In the case of SNWA GIS, the enterprise ArcSDE is fully compressed every month. During the process of a full compress, all versions are consolidated and removed, and all adds and deletes are moved into the "base/business" tables. Bottom line for check-outs, until the technical obstacles preventing a replica from surviving through a full compress are removed, replicas have a finite lifespan.

For One-way and two-way replicas, the problem is slightly different. As documented in the ArcGIS help system, these types of replicas require ArcSDE for both participating geodatabases. Most enterprise ArcSDE users only have one instance running; this is also the case for SNWA. In order to make effective use of two-way replicas, an organization would need to have two separate enterprise ArcSDE running in two separate Oracle instances! The cost and complexity of this configuration is prohibitive for most organizations. There is a less-costly solution, which is the use of Workgroup ArcSDE, as one of the geodatabases participating in the replica.

Future Directions for SNWA GIS

Because of the potential benefits of Workgroup ArcSDE and participation in two-way replication, the KTM division may soon be investigating this option for SNWA GIS. One likely configuration wherein Workgroup ArcSDE and enterprise ArcSDE will co-exist is shown below. In this configuration, the enterprise ArcSDE is a subscriber of Workgroup ArcSDE. All routine data maintenance would occur within Workgroup ArcSDE; business processes would contribute or revision the workgroup GIS data layers. Periodically, the enterprise ArcSDE layers would be refreshed through its one-way replica subscription. It is unknown at this time if this configuration will enable SNWA GIS to realize the full benefits of two-way replication.
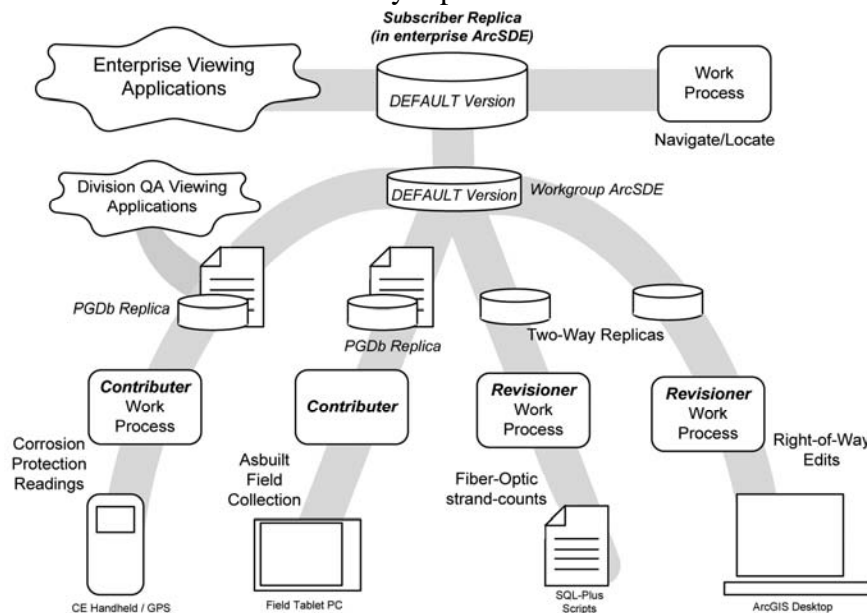
Conclusions

The extension of enterprise ArcSDE through the use of replicas has been successful in SNWA GIS data maintenance processes. While the traditional "check-out" replica resembles a simple edit version, there is more to replicas than mere versioning. Careful research and understanding of the 1) effected business process and 2) how data flows between systems can and should determine which type of replica is implemented for each business need. For SNWA GIS, a number of specific data maintenance efforts rely on replicas. The benefits to our organization may be increased in the future by implementing additional replica types as dictated by both the availability of computing resources and the needs of SNWA as an organization.