ArcSDE™ CAD Client

An ESRI® White Paper • April 2001

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Description

General Description of ArcSDE CAD Client

ArcSDE™ CAD Client is a no-cost extension to ArcSDE that provides an interface for AutoCAD and MicroStation to access ArcSDE-managed data. ArcSDE CAD Client is one of several client software applications and/or extensions available from ESRI that provides a link to the spatial data managed by ArcSDE in a database management system (DBMS). ArcSDE is ESRI's gateway for managing GIS vector, raster, and computer-aided design (CAD) binary data in a DBMS. Other ESRI® ArcSDE clients include the ArcGIS™ 8 desktop clients, ArcView® GIS 3.2, MapObjects®, ArcExplorer™, and ArcIMS® 3.x as well as custom applications created using the open published ArcSDE C application programming interface (API) or Java API.

ArcSDE CAD Client, hereafter referred to as CAD Client, is a software application from ESRI that enables Autodesk's AutoCAD® or Bentley Systems' MicroStation® software to be spatial data clients of ArcSDE, the spatial data warehousing software from ESRI. CAD Client is a CAD-based application that communicates with ArcSDE and provides a means for CAD operators to store and retrieve data to and from an ArcSDE-managed spatial database. CAD Client uses the current CAD session as the graphic engine to perform spatial data transactions.

The individual entities or elements of a CAD drawing can be stored into a database managed by ArcSDE by reading the CAD geometry and converting it into ArcSDE geometric features. The ArcSDE geometric data model consists of points, various line forms, areas, and annotation. In addition to storing the geometry in the ArcSDE feature format, a binary copy of the CAD object with all of its parametric geometry and graphic CAD properties can be appended optionally to the ArcSDE geometric feature.

The binary copy of the CAD object that CAD Client stores preserves the parametric CAD geometry along with all of the CAD properties, symbology, and extended CAD attribution such as MicroStation *mslink* values or AutoCAD extended entity data. When CAD Client retrieves data from an ArcSDE-managed database that was previously stored using CAD Client, the CAD user has access to the binary CAD object. The ArcSDE geometric feature data is available to all ArcSDE mapping client software including CAD Client, the ArcGIS 8.1 desktop clients, ArcView GIS 3.2, MapObjects 2.x, and ArcIMS. The CAD version of the data is not accessible outside of the CAD host with which it was stored.

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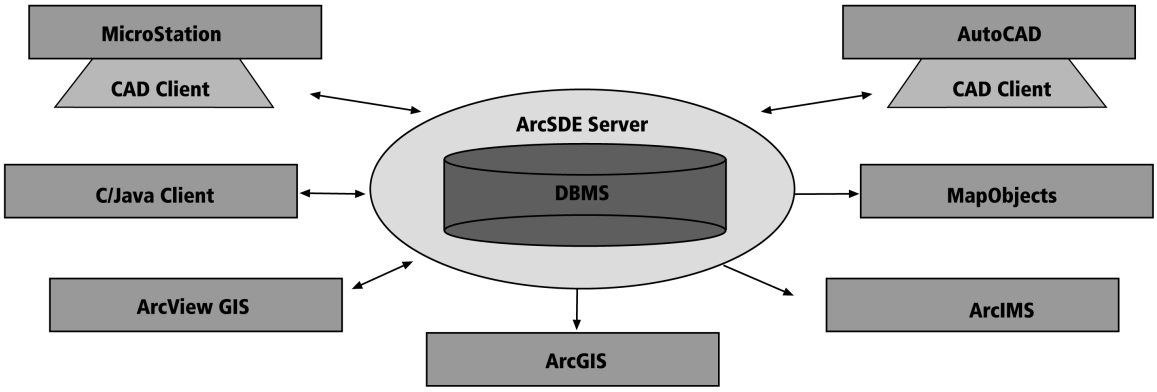
The Role of Other ArcSDE Client Software

ArcSDE client applications from ESRI include the ArcGIS 8.1 desktop software (ArcView 8.1, the new ArcEditor™, and ArcInfo™) ArcView GIS 3.2, MapObjects 2.x, ArcExplorer, and ArcIMS 3.x as well as custom applications created using the ArcSDE C or Java API. Each of these client applications provide a different user environment from which to view, query, and/or edit ArcSDE-managed spatial databases.

ArcSDE Server in Enterprise Configuration



ArcSDE Software's Role

ArcSDE is ESRI's gateway technology for storing and managing spatial data in a DBMS. ArcSDE provides a GIS application server functionality to perform fast, efficient spatial operations against large, shared geographic data sets. Storing spatial data in an ArcSDE server offers significant advantages over other methods including

- Logically continuous spatial object model
- Shared multiuser environment
- Database and schema portability
- Support for out-of-box CAD and GIS client applications
- Support for large spatial data sets
- Storage of both native CAD objects and ArcSDE geometric features
- Full suite of existing client mapping software
- Efficient spatial data retrieval
- High-performance spatial searches
- Open systems client/server architecture that employs cooperative processing
- Powerful application development environment

ArcSDE is ESRI's gateway technology that provides the ability to store, retrieve, and query spatial data along with its corresponding tabular attribution information. ArcSDE brokers requests from various client mapping applications to store, modify, or query spatial features and their accompanying tabular attributes. ArcSDE processes these requests and translates them into processes, actions, and queries to manipulate the underlying DBMS. ArcSDE works with major commercial databases including IBM DB2, Informix, Microsoft SQL Server, and Oracle.

ArcSDE processes the requests of client applications and manages the spatial data in the underlying databases. In some cases the underlying database may be an ArcInfo coverage; in other cases it may be a DBMS such as Microsoft's SQL Server, Oracle, or others. When managing a DBMS, ArcSDE software's job is to manipulate the tables, indexes, and SQL queries in the most efficient and practical manner—for that host database—using a variety of storage schemas and data structures. ArcSDE engineers have built on the tools of the host DBMS to provide the fastest and most efficient indexing, query, and data structures provided by that host DBMS. In some cases there may be options to choose a desired data structure alternative as is the case with Oracle databases.

CAD Client Features

Functions

ArcSDE CAD Client has five simple, yet powerful, functions. This well-defined set of tools allows the CAD user to STORE, RETRIEVE, EDIT, and IDENTIFY spatial data managed by ArcSDE. The fifth function is a combination of the first four functions, which is the extensible CAD Client API. The API of CAD Client is provided in the programming environments of each of the CAD hosts.

CAD Client STORE Function (Data Creation)

The STORE function interface allows the user to predefine a set of parameters that define the ultimate storage location and how various geometric and graphic properties are mapped from the CAD environment to the database schema of the target spatial database being managed by ArcSDE. These parameters are collected in what is called a *store template*. The store template includes information about the target database and instructions as to which graphic CAD properties you would like to map into which DBMS data column.

CAD Client stores individual CAD entities as records in a database. A CAD design file or drawing can be seen as a *container* of multiple spatial features. During the STORE process, the graphic properties and the CAD file name can be used to populate the column values for the target record in the DBMS. By simply querying back all the objects based on that stored drawing name, you can re-create a CAD drawing with all the CAD objects that it originally contained. You may also want to make use of seed drawings to store layer, font, and symbology information that is not stored by CAD Client as part of the CAD objects.

CAD Client will store either a selected set of CAD objects or all the objects in the CAD file. During the STORE process, CAD Client will take each CAD object and submit a request to ArcSDE to create a new record for each in the underlying database. The ability to create a seamless repository of spatial features without regard to smaller tiles or CAD files is a distinct advantage of CAD Client over other CAD mapping solutions. Queries can be made across what used to be tile boundaries or various map sheet layers.

In CAD mapping applications it is common to tile data into smaller data containers to make the drawings smaller and generally more manageable within the CAD environment. CAD Client, along with ArcSDE, provides a tileless, industry-standard, multiuser database environment to use as a container for spatial mapping data.

A CAD user can choose to store a binary copy of the CAD object and/or just the ArcSDE geometric feature interpretation of that CAD object. Advantages to storing the binary CAD object are that the CAD user will get back essentially the same entity they originally stored, along with its graphic properties and extended attribution information. Also, the storage of the binary CAD object provides a means to replace the concept of CAD files altogether, a capability especially attractive for the storage of basemap data. However, you may find that your work flow requires you to maintain the CAD files for historical or other purposes. Uses of CAD Client and database design issues will be presented later in this document.

You may choose not to have CAD Client store the binary CAD object if you intend the data to be edited by ArcSDE client software other than CAD Client. Only CAD Client can modify data stored with binary CAD data attached. ArcSDE data becomes read-only to non-CAD Client software when the CAD objects are included because only CAD Client can interpret and modify or create this type of data. Data stored in CAD without the CAD object attached is indistinguishable from data stored by other ArcSDE client software and, as such, is editable by all. Likewise, CAD Client can edit the geometric features managed by ArcSDE regardless of which client stored the data, with the exception of ArcGIS geodatabases and versioned ArcSDE databases.

The capability to store the binary CAD object is available on all versions of ArcSDE except those databases that are read-only such as ArcSDE for Coverages and geodatabases. Storage of the binary CAD object is also not permitted in ArcSDE with Oracle Spatial using a *normalized* table schema. The Oracle Spatial normalized table schema does not have the capability to store the extended geometry information needed to support the CAD binary data format. Also, because non-CAD Client applications may have access to Oracle Spatial data, edits to the spatial data may compromise the integrity of the data by modifying the geometry of the spatial feature without regard for the CAD object.

CAD Client RETRIEVE Function (Query)

The RETRIEVE function has a template similar to that used for storing data. CAD Client uses reusable, predefined queries to populate the current CAD drawing with spatial features from a database managed by ArcSDE. These retrieve templates are nothing more than stored queries. These queries can combine both spatial and attribute constraints to select just those objects that you wish to retrieve into the drawing session. The retrieve templates also include a parameter to retrieve the CAD binary object or the ArcSDE geometric version of the feature. Logically, this option is only available on data in which this binary CAD data was stored. In other words, you can only retrieve CAD binary objects if CAD Client stored the object originally.

Data retrieved from a query is expressed in the CAD session as new CAD objects. CAD Client will get a stream of geometry back from a query that it uses to construct brand new geometry on the current level using current graphic property settings. An exception to this would be when a binary CAD object is retrieved. In these cases the binary CAD object is introduced into the current session, and it brings with it all the information to reconstruct the entity or element as it originally existed when it was stored.

Some extended attributes of CAD objects can only be fully realized within the same extended CAD application environment. Such is the case for AutoCAD "custom objects" and "object data." If the application that defined the custom object is present, then the re-created CAD object will have all of its original properties and behaviors. If the AutoCAD application is not loaded, then the retrieved custom object will be treated as a proxy object. This is the same behavior that AutoCAD uses when one loads a drawing of custom objects without the application that defined them.

CAD Client does not distinguish between different instances or database vendors of data managed by ArcSDE. Data stored in an ArcInfo coverage managed by ArcSDE for Coverages is just as accessible as data in Oracle Spatial being managed by ArcSDE for Oracle. As discussed in the architecture section of this document, this client/server architecture allows the ArcSDE client software to access multiple servers simultaneously and without a need for different versions of the client software to read different data servers.

CAD Client provides the following *spatial* query operators that can be used to select spatial features:

- Polygon Pass-thru Within and crossing a selected polygon
- Polygon InsideInside a selected polygon
- IntersectingIntersecting a selected point, line, or polygon
- Entire Layer All features in the ArcSDE layer
- Current View WindowWithin the current CAD view window
- Buffer InsideInside a specified buffer of a selected point, line, or polygon
- Buffer Pass-thru Within and crossing a specified buffer of a selected drawing object
- Common PointAll features that share a common point
- Common LineAll features that share a common point

CAD Client attribute queries are specified using a "WHERE" clause conforming to the standard SQL query syntax of the underlying database.

In a single session, a CAD operator in MicroStation or AutoCAD can access data from coverages and shapefiles via ArcSDE for Coverages, the spatial type of Oracle Spatial, ArcSDE software's compressed binary schema, the Informix Spatial DataBlade, and IBM's DB2 Spatial Extender.

CAD Client EDIT Function (Data Modification)

CAD Client relies solely on the editing tools of the host CAD environment to perform all the geometric editing operations. Because all objects retrieved by CAD Client are represented in the host CAD environment as CAD objects, the existing tools in the CAD host are sufficient to perform any geometric modification you might wish to perform. This includes objects that were stored into the DBMS from ArcSDE software clients other than CAD Client.

The process of modifying ArcSDE features requires the understanding that ArcSDE-managed spatial data resides in a DBMS. And as such, the methods for making changes are more akin to making a database transaction of a selection set of database records, which is what they have become.

The process of editing involves aspects of both the STORE and RETRIEVE functions. A store template controls the way in which objects that are edited are returned to the database. Where the new data is placed and which attributes are retained are controlled by the selection of a store template. Also you must perform a RETRIEVE function before there are any objects in your working drawing in which to edit.

Once checked out for editing, feature locks are placed on all spatial objects of a given ArcSDE layer within the geometric extent of the select objects. All other simultaneous users will be given read-only access to that data until the editing session is concluded or abandoned. All disrupted editing sessions are abandoned.

During the editing process, one selects a group of objects that will be modified and then selects the start editing function. Additions, modifications, and deletions may then be performed using the native CAD tools. Once all editing for that session has been completed one then reselects the objects to be modified or added to the databases. Missing objects are assumed to have been deleted, new objects are added, and modified objects are updated. You have one last chance to accept or reject changes before they are committed to the database.

CAD Client IDENTIFY Function (Tabular Attribute Editing)

The CAD Client has a database IDENTIFY tool to view and modify the tabular attributes associated with the spatial mapping feature within the CAD environment. The IDENTIFY tool displays the attribute record values for a selected feature in a dialog box. Modifications to the tabular attributes through the IDENTIFY tool are made directly to the underlying database being managed by ArcSDE. Storing CAD data into ArcSDE-managed databases implies that each stored object has a record in the database in which attributes can be managed. CAD Client gives a direct connection for attributes to the underlying database without the need for any CAD-based applications such as AutoCAD Map, ASE, Geographic, or others.

CAD Client Application Programming Interface

The CAD Client API tools are available in AutoLISP, ADS, and Object ARX, as well as the Component Object Model (COM)-based tools using automation APIs for COM-compliant programming environments such as Visual Basic, Visual C++, or Delphi. The exposed function calls of the API include all those commands accessible from the graphic user interface as well as additional query functionality and a very powerful SQL pass-thru function.

The SQL pass-thru function allows the CAD Client developer to perform database functions in conjunction with their CAD Client application. A developer could use this function to perform queries; create, update, or delete tables; perform joins; or any number of other database tasks.

CAD Client developers can build applications that extract their own proprietary data from their CAD elements to populate the tables managed by ArcSDE. Oftentimes complex attribution techniques are implemented to encode the tabular attributes of CAD objects in a CAD file. Because these methods are often nonstandard and cumbersome, you will find managing these attributes in an industry-standard DBMS using ArcSDE to be far superior to CAD-based methods.

Database Security

CAD Client is a client of a DBMS and requires that a CAD operator log in to the database to make transactions with the database. User permissions and security issues are all handled by the underlying DBMS. Therefore, before storing, retrieving, or editing data from the DBMS, your database administrator must establish the proper permissions to access the database. The person administering the DBMS will handle this as a database function, and only the user name and password will be the responsibility of the CAD user.

Because ArcSDE is a gateway application, it can take advantage of all the tools for security, backup, recovery, fail-over, and so on, of the underlying database. This is a distinct advantage over file-based mapping solutions with limited provisions for security and recovery.

System Requirements

Personnel

CAD Client is designed for use by CAD operators. The CAD Client interface is presented using the CAD menus and toolbars. Dialog boxes and wizards guide the CAD operator through the process of storing, editing, identifying, and retrieving data.

Because CAD Client is a component of an enterprise GIS system, it is suggested that a person familiar with the concepts of GIS be available to design and maintain the databases, policies, and work flows involved in an implementation of CAD Client with ArcSDE.

ArcSDE is a DBMS server application and should be administered by a person qualified to administer the underlying database. Daily maintenance of databases, backups, security, and networking are skills required by a person implementing an enterprise GIS system that includes ArcSDE and ArcSDE CAD Client. One exception to this would be the implementation of CAD Client solely in conjunction with ArcSDE for Coverages. ArcSDE for Coverages has no underlying DBMS. ArcSDE for Coverages provides read-only access to file-based ArcInfo coverages.

Server System

The system requirements for a server running ArcSDE vary dramatically based on the number of users, speed and type of the network, and the chosen underlying database. There are no special or different requirements for a server due to the use of CAD Client except when making large transactions. For example, during a time of loading large amounts of CAD data in a batch mode, you should expect to experience a larger load on the network and the server. One can see, however, that this is more a function of the operation being performed rather than anything specific to CAD Client.

The size of an ArcSDE-managed database can be several times larger than the combined sizes of the CAD files that originally contained the objects. This is due to the fact that in addition to the CAD object definitions, there are now database tables of attributes, a GIS geometric definition of the object, as well as indexes and potentially object-specific cell and block definitions. Therefore, the ratio of data storage expansion can be significant especially on data dense with AutoCAD block definitions.

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Desktop System

CAD Client installs on top of the chosen CAD platform and runs on the same machine as the CAD application. CAD Client software's required disk space and additional memory footprint are relatively small and do not warrant any special attention. One need not consider the system requirements of CAD Client when sizing a system. The system requirements of the chosen CAD software are sufficient when determining the size and speed of the desktop system running CAD Client.

ArcSDE and Supported CAD Platforms

- ArcSDE 8.1.x—AutoCAD (R14, 2000, Map 2000, 2000i), MicroStation (95, SE, 'J', 5.x–7.x)
- ArcSDE 8.1.x for Coverages—AutoCAD (R14, 2000, Map 2000, 2000i), MicroStation (95, SE, 'J', 5.x–7.x)
- ArcSDE 8.0.x—AutoCAD (R14, R14 Map), MicroStation (95, SE, 'J', 5.x–7.x)*
- ArcSDE 3.x for Coverages—AutoCAD (R13, R14), MicroStation (95, SE, 5.x)*
- ArcSDE 3.x—AutoCAD (R13, R14), MicroStation (95, SE, 5.x)*

* Listed for historical record, may no longer be available on all platforms.

CAD Client Uses

CAD Client has a number of basic uses. The following are not intended to be an exhaustive list, but rather some common uses of the software.

CAD Basemap Management

One simple use of CAD Client is to create a large repository of CAD basemap data. In such an implementation, the organization may start with a large volume of CAD data in many separate CAD files. Using ArcSDE and CAD Client these organizations create a seamless, tileless database of CAD objects in a multiuser CAD environment. The basemap data is no longer locked into individual CAD files but is in a single CAD database repository of spatial features accessible to both CAD users and GIS users.

This form of implementation is made possible because the binary CAD object can be stored and retrieved without any loss of symbology, attribution, or geometric complexity.

Internet CAD Data Publishing

Another implementation, similar to the one described above for CAD basemap management, is the ability to publish a basemap of CAD data to the Internet or Intranet. Because the storage of CAD data into a DBMS managed by ArcSDE requires the automatic creation of GIS spatial features, other ArcSDE software clients such as ArcIMS have direct access to this excellent translation of all the CAD data stored in the DBMS.

By simply creating a connection to the same ArcSDE-managed DBMS, organizations can publish their spatial CAD data to a Web server for Internet or Intranet viewing using ArcIMS. Users need only target their Internet browsers to the ArcIMS server of this data to access all the spatial CAD data stored in the ArcSDE-managed database.

GIS Server of CAD Data

In organizations that primarily perform GIS functions but rely heavily on CAD for a source of data, CAD Client can act as the conduit to the centralized GIS repository. GIS users then have direct access to the CAD data using their preferred tools of ArcView, ArcGIS, ArcInfo, ArcIMS, and so forth. The CAD users can publish this information directly into the DBMS from within their CAD environment.

Once published, the CAD information can be accessed by GIS users without requesting the information from CAD users and without the need for GIS users to learn the file naming conventions or some other project management software. There is no need to have the data exported or converted into a special format because that function was performed when the data was stored using CAD Client.

CAD Server of GIS Data

The reverse of the above situation is also common. In such cases the basemap information is created and maintained by the GIS group. The GIS group creates, manages, and edits all the basemap information. For example, the engineering or other project groups need to have access to this basemap information within their own CAD environment to build new construction plans or to perform some CAD-based plan or analysis. In this scenario, CAD Client provides a CAD-based interface to browse, query, and extract the needed basemap information without the need to request the GIS group and without the need for a special intermediate file format or data conversion.

Integrated CAD/GIS Spatial Data Warehouse

Some organizations need to share the responsibility for the construction and maintenance of the basemap. Sometimes the GIS group is making modifications in the form of a new planning study or new maintenance. At the same time engineering may have as-built plans to add or modify. In such an organization, ArcSDE CAD Client provides an interface where both the CAD user and the GIS user have access to the same basemap data in a centralized multiuser DBMS. Each is equipped with their own set of software tools in their own environment—GIS applications for the GIS users and the CAD environment for CAD users. Each user can use its own set of viewing and editing tools. Both have access to spatial- and attribute-based queries, and both have the ability to make maps.

In such a mixed environment, ArcSDE CAD Client is the tool that links the CAD user to the enterprise database of spatial data. CAD Client provides the CAD interface to the neutral database of spatial information that can be accessed and modified by both CAD and GIS users simultaneously.

GIS/CAD Conversion Tool

One often overlooked function of CAD Client is the wholesale conversion of CAD to GIS data and GIS to CAD data that happens during the simple process of using CAD Client. For example, when using CAD Client with ArcSDE for Coverages, CAD Client provides a direct query-based access to ArcInfo coverages. Likewise data stored in a DBMS version of ArcSDE by CAD Client provides an excellent translation of CAD data into a GIS format directly accessible to all GIS ArcSDE client software without an intermediary file or further conversion.

CAD-Based ArcSDE Editor

Some organizations have a need to perform edits on their spatial information managed by ArcSDE but have more CAD editing experience in-house than they have skilled GIS editing personnel. In such cases CAD Client can be used to leverage the existing CAD experience to edit the data in the ArcSDE-managed DBMS.

A situation may arise where consultants or others with only CAD experience may be required to edit or modify ArcSDE-managed data. CAD Client provides this CAD-based ArcSDE editing environment.

Software Architecture

ArcSDE Server

CAD Client is a client application in a three-tiered software solution. The other two components of this software system include ArcSDE spatial gateway technology and a DBMS.

CAD Client communicates its requests to ArcSDE via a TCP/IP network connection. ArcSDE is run as a service on the DBMS server, but it can also be run on a separate server when the DBMS is installed on server hardware not supported by ArcSDE or where an organization's information technology rules dictate that application server software must be installed on a server separate from the server on which the DBMS resides. ArcSDE listens for requests from any client application. When these are received, ArcSDE converts these requests into the appropriate action within the database it is managing.

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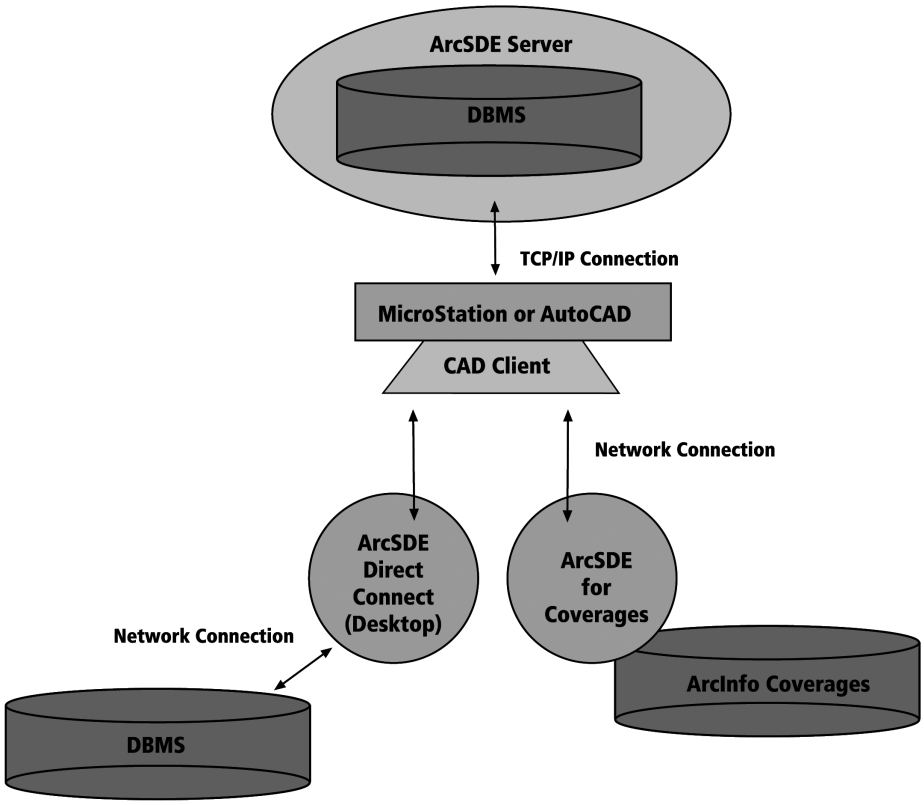
Alternate ArcSDE Connections



ArcSDE Direct Connect

There is also a two-tiered ArcSDE solution. In the case of ArcSDE Direct Connect, CAD Client has read-only access to ArcSDE-managed databases. The ArcSDE Direct Connect drivers allow clientside management of databases. These drivers do not require the ArcSDE serverside application to manage the underlying database. Instead, ArcSDE clientside drivers directly manage the underlying database to form a two-tiered rather than three-tiered architecture. Communication between the desktop and the database is conducted over the network. In certain cases additional networking software may be required such as *Net8* for Oracle.

Choosing which method of database connection is right for you, ArcSDE standard application server or clientside drivers, will be determined by a combination of your desktop/server/network systems' dimensions, requirements for hot-failover, network bandwidth, number of users, performance, and application needs.

CAD Client Application

CAD Client is run from within one of the two host CAD environments, AutoCAD or MicroStation. CAD Client is a single application with four core components. It has an interface module that controls the user interface dialog boxes, a CAD stub that communicates with the CAD user interface and the CAD file, an ArcSDE Client interface that communicates with ArcSDE, and finally an application programming interface that allows the user to access the functionality of CAD Client within the native programming

interfaces made available within the host CAD environments. CAD Client installs on the CAD workstation and is launched as a single application from within AutoCAD or MicroStation.

GIS/CAD Integration Issues

Database Design

The way in which data is organized within a database is known as database design. Choices are given to database users as to where data is stored and what attributes are maintained. When dealing with ArcSDE-managed databases, you also have choices about which geometry types are stored and how they are maintained.

Ultimately your database design should be determined by how the data will be used in your applications. For example, if the sole use of the data was as a repository for the geometry of CAD drawings, then a database design that includes all of the geometry in a single location would be the most efficient. In such a database design all the different objects would be available with a single query to the ArcSDE database.

However, if your applications focus on the use of a selected system of objects, such as a sanitary sewer system, where various pipe attributes and descriptive information is being stored and maintained, you may want to have a separate database layer just for the lines of the sewer system. Other supporting information in the CAD drawing, such as street centerlines or right-of-way lines, could be stored in a separate database layer or layers. If one chose to put all the information in the same database, it may become awkward and confusing to have such descriptive attributes as pipe diameter or material type included on all the nonsewer system data.

This is not to say that you must separate all the geometries of a CAD drawing into separate layers if you intend to query these sets of data. By making judicious use of queries and database table relationships, you could still keep the data together by building relationships between tables using a unique key. In such a case, the material type or diameter attributes could be stored in a separate table and only viewed when querying the sewer system. ArcSDE layers can be built on a database where the relationship between database tables has already been established.

Because ArcSDE is a database application, issues dealing with database design are the same as the issues of the underlying database and in all cases should be designed with the involvement of the database administrator to ensure proper security, performance, and reliability.

Enterprise Project Management

CAD Client is simply one tool you can use to accomplish the tasks of an enterprise. The more well defined your tasks, the easier it is to implement and maintain a software system to help you manage it. Before using CAD Client with ArcSDE, it is strongly suggested that you assess and identify the users of the system, their skills, and their application needs to ensure that there is a well-defined benefit to each of these users and/or to the organization as a whole.

Although CAD Client uses are varied and powerful, it is always imperative to a successful implementation of CAD Client and ArcSDE that you create a limited scope to your initial efforts. This limited scope helps to ensure that your efforts will indeed be successful. A string of small successes are the key to the implementation of any GIS system. These incremental successes give confidence to the users and spawn new uses and priorities helping you discover how to best leverage your software, data, and the human resources.

Time and again one can see that a lone champion of a GIS system can create a history of small successful applications in an organization, which has a greater impact than a legion of committee members attempting to solve all the problems of an enterprise in just the design phase of a project during the same span of time.

Coordinate Systems and Projections

The de facto standard coordinate system of CAD is to assume that the universe is a cube. Engineering and survey work symbolized in the CAD environment generally assumes a flat earth surface over an acceptably small area. In cases where larger areas are mapped, it becomes necessary to define some method to deal with the curvature of the earth. Cases arise during the implementation of CAD Client when drawings intended for local use are joined together to form a larger basemap. In such cases what was 10,000 individual CAD files depicting construction plans for fiber-optic cable lines becomes a basemap of a nationwide network. These drawings were never intended to be used together, and although each may have been surveyed and constructed with an accuracy of a thousandth of an inch, when assembled they will not fit.

When attempting to assemble a large area of CAD files, there comes a time when one must deal with the assumptions and limitations of the coordinate system that was chosen. The only mathematically correct method to record the surface of the globe is to use spherical geometric tools and some type of spherical coordinate system. Spherical editing tools are impractical and unnecessarily complex for the majority of mapping applications. Therefore, one must accept the limitations of a selected coordinate system and the distortions invoked by choosing a particular coordinate system.

For example, when using a State Plane coordinate system for a particular region, one accepts the fact that the distance and direction between objects depicted on a map will be distorted the further from the center of the area being covered by that region. It has been decided that areas outside of a particular State Plane or other geographic zone may cause distortions that are unacceptable for a particular application or mapping use. When one tries to use data from outside that particular region, one must project the data from one projection to another. In doing so, one must accept the distortions inherent of both the projections and the methods used to move the data from one projection to another. The distortions of a particular projection are well-defined. Sometimes less defined are the errors or distortions caused by the method of projection. These distortions are caused by mathematical and computer round off and by the cumulative distortional effects of going back and forth between potentially multiple transformations over the history of a data set.

The issue becomes increasingly more complex when CAD data is brought into the mix. Generally, it is accepted that GIS data is a collection of points. Curves are often represented as a string of points to approximate a curve. When this type of data is

projected from one projection to another, the individual points are modified to their new positions. Shape is one of the distortions caused by attempting to portray a spherical earth as flat. Therefore what used to be a circular curve is now some form of a squashed elliptical curve.

CAD users are often not willing to accept some of these shape distortions when moving data from one projection to another. Although the projection may be mathematically well-defined and acceptable to a CAD user, the projection may cause an unacceptable shape distortion. There is nothing that can be done mathematically to resolve this problem.

One must understand that neither the accuracy of the data nor the software generated this distortion. The distortion was introduced into the data by the coordinate system that was chosen when the coordinates of the shape were initially recorded. CAD users want to project their data, yet still expect to maintain their circular curves. To accomplish this, they must accept a situation where a custom hybrid projection is used. This situation creates a nonstandard projection where some of the shapes are distorted and others are not.

There exist some software tools to do this type of hybrid conversion, but be warned that there is no way to actually project a circle and have it retain its circular shape unless the projections involved are ones that are specifically designed to retain shape. Therefore, you must choose which of the distortions you wish to accept when mapping large areas or converting data from one projection to another. Some form of shape, distance, area, or directional distortions will always be present when mapping the curved surface of the earth onto a flat map or computer screen.

Document Management

Because of the database storage and retrieval capabilities of CAD Client, it is a common mistake to jump to the conclusion that CAD Client is a document management system. Although CAD Client can be used as such, it was not designed to be one, and many of the facets of a dedicated document management system would become the responsibility of the user. It is true that one could store and retrieve the contents of CAD files into the DBMS and query and edit what used to be the contents of those files. However, the fact remains that ArcSDE is a mapping software that organizes spatial features rather than documents. The container known as a CAD file no longer exists for data stored in ArcSDE. The only record of the old file name may be a tabular attribute in the record of each of the CAD objects that used to be stored in that CAD file.

ArcSDE has no concept of a CAD file. CAD Client does not store CAD files but rather it can store the objects contained in CAD files. ArcSDE manages spatial features and is most effective when dealing with tileless repositories of spatially oriented mapping data. If CAD Client is used as a document manager, it suffers because the user would have to build the application interface as well as much of the logic to support basic functionality that would be expected in even the most basic document management systems.

Working with Reference Files

Existing CAD systems have adopted various referencing and tiling strategies to successfully manage large amounts of CAD information. Limitations on the graphic capacities and performance of the desktop CAD systems necessitated the adoption of

these techniques. Because of the database structures used by ArcSDE, the limitations on the size of the data have been removed. ArcSDE excels at the storage and fast retrieval of data across huge amounts of spatial information. One is still limited by the capacity of the CAD program when viewing large amounts of data. One could not, for example, store 10,000 drawings into ArcSDE and then query the contents of those 10,000 drawings back into one CAD session. The advantage of ArcSDE and CAD Client is to query across all the data and retrieve only what you need to see.

CAD Client makes the need for tiled or referenced drawings obsolete. When storing the contents of CAD files using CAD Client, these referenced drawings are not considered part of the current CAD file and are not stored during the storage operation for that file. To store the contents of these related CAD files, one would store each of these reference files individually. These reference files then become part of the tileless repository of spatial features.

Historically, data may have been organized in tiles and then applications may have built upon these arbitrary boundaries. In such cases one might choose to include the geometry of the boundaries themselves as spatial features to assist in the query or designation of tiles in a database. Furthermore, the original drawing name stored as a tabular attribute can be useful to label and maintain these fictitious tile boundaries.

Complex CAD Attribution Schemas

The attribution of CAD objects is somewhat of an afterthought for AutoCAD and MicroStation. CAD Client spatial features, on the other hand, maintain both their geometry and their tabular attributes in the same record row of an industry-standard database. At last count there are nine distinct methods of tabular attribution in AutoCAD and MicroStation. None of these CAD attribution methods are sufficient when dealing with large amounts of spatial data in the form of a GIS. Oftentimes these methods of attribution are only understandable by the application that stored them. CAD Client provides a means to store tabular attribution on all objects stored in the DBMS managed by ArcSDE. This attribution capability is inherent in the data model and is available to the CAD operator without any additional steps. The adoption of CAD Client makes these other means of internal and external database attribution obsolete.

CAD Client and the Geodatabase

CAD Client is a client of ArcSDE and has the capability to edit spatial features in a database managed by ArcSDE. ArcSDE manages two distinct types of spatial data. The first is the ArcSDE simple feature layers and the second are those geometric feature layers that are part of a geodatabase (the native data format of ArcGIS). The geodatabase has properties, methods, and behaviors that are stored along with the data, such as geometric connectivity rules and attribute domain constraints, which set limit ranges and cardinal choices for column values. These types of extended database definitions are only manageable within the ArcGIS environment. To avoid violating these rules and corrupting these extended database definitions, CAD Client offers read-only access to geometry managed within an ArcGIS geodatabase.

The same is true for versioned ArcSDE-managed databases. In ArcGIS you have the ability to create versions of a database that can be maintained with a sophisticated history and rollback functionality. There are tools in ArcGIS to merge versions and to perform long transactions with the data. There are no such tools found in CAD Client. To ensure

the integrity of ArcSDE databases, CAD Client provides read-only access to versioned databases.

Mixed CAD/GIS Environments

In a mixed environment of CAD and GIS there are some steps that can be taken to make the transfer and conversion of data between the two systems as simple as possible. For example, being consistent with layering and symbology within CAD files makes the files much more useful within a GIS. The single most important step a CAD manager can make to ensure their data is the most useful in a GIS is to adhere to strict standards of layering, color, and line styles. Judicious use of consistent CAD standards provides a useful means of attribution that can be leveraged by a GIS system.

Another useful technique to smooth the sharing of data between CAD and GIS is to uniquely identify objects using CAD standards. For example, you can uniquely identify different types of valves in AutoCAD by using different types of block symbols. Similarly, you can use color to distinguish between different pipe materials or possibly line thickness to denote diameter. Consistently placing text near the midpoint of a line or inserting a descriptive bock or cell symbol in the middle of a closed polygon to define an area are all useful when data is to be used in the future as a GIS.

Summary

ESRI is a GIS company that focuses exclusively on providing superb GIS functionality to its customers. Because there are diverse groups of people who desire to perform GIS functions in many different disciplines and working environments, ESRI creates applications that best fit those environments. It is the goal of ESRI to provide software products that best fit the working environment of its users. For some, that environment is a Web browser, for others it is a handheld personal digital assistant (PDA), and for the CAD user it is CAD.

CAD Client is presented as a no-cost add-on product to ArcSDE that allows AutoCAD or MicroStation users to be clients of the spatial data warehouse. CAD Client can store exact binary copies of CAD objects, and at the same time it creates a GIS representation of that same feature in the ArcSDE-managed database. This gives each person in a mixed CAD/GIS organization access to their data, and each other's data, in the appropriate environment and data format. CAD Client gives access to spatial data originating from a GIS source equally as well as data originating from its own CAD environment. CAD users can store CAD objects and retrieve CAD objects or GIS objects from within CAD, while the GIS user sees the same objects as GIS data from their own environments.