GIS Through the Looking Glass

Terminal Services and Thin-Client GIS

Jonathan W. Lowe

Terminal services are the latest mechanism for delivering full-featured GIS functionality to remote users, creating a wonderland of possibilities and questions.

What's wrong with this picture? At the hotel the night before a conference, Jane connects her laptop to the Internet using a 56k dial-up modem and checks e-mail. Afterward, she fires up ESRI's (www.esri.com) ArcMap for a late-night editing session. As usual, the splash screen's multi-colored map images and superimposed number eight springs to life on the desktop (see Figure 1). "ArcMap™" it says in large black letters, "GIS by ESRI™." Moments later this yields to the familiar user interface of ArcMap itself, with a list of themes stacked on the left and rows of tools along the top, all framing a map (see Figure 2). Newsworthy? Hardly — more like mundane. Just another day in the life of a typical desktop GIS user. But wait, what if one contradictory detail enters the narrative: everything in the story above happened exactly as described, but Jane's laptop never had a single ESRI product installed on it. How, then, did she fire up ArcMap?

Today's news is the growing popularity of inexpensive, extremely lightweight application delivery technologies that allow even low-bandwidth dial-up users to simulate the ArcGIS desktop experience on any Internet-connected computer. The word "technologies" is plural because there are two options, Windows Terminal Server (www.microsoft.com) or Citrix Metaframe (www.citrix.com). Both support variations of the same general idea.

That idea is simple. Compare it with traditional desktop applications that use the local computer's CPU to process locally installed application code and data, both stored on local disk. In contrast, using terminal services, applications run on a central server for access by multiple users. The terminal services

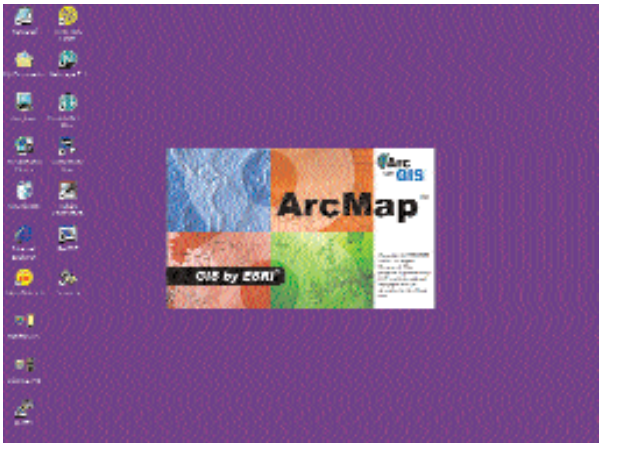

FIGURE 1 With terminal services, a remote user can access ESRI's ArcMap as if it were loaded on his or her local computer. From the user's perspective, such access is seamless, with the program even announcing its imminent arrival with the usual splash screen.

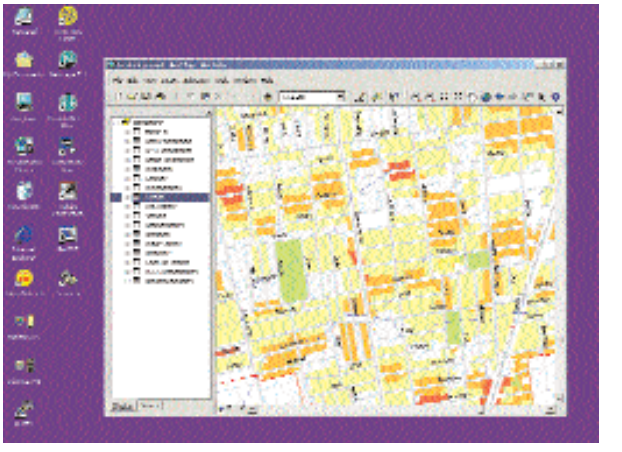

FIGURE 2 ESRI's ArcMap, accessed via a terminal services connection, displays spatial data on the desktop of a remote laptop user.

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client software captures mouse clicks and keystrokes on the local computer, sends them to the remote server for processing, and returns only the display images of the application to the local client screen. So, for a user interaction such as a zoom or pan, the application processing is performed on the server, and the resulting screen images are transmitted to the client PC, creating the illusion of a local program. The application, data, and CPU processing are all remote. It's like piloting an empty, but real, jet from a remote-control flight simulator — as genuine as the flight feels, all you really touch is a looking-glass copy.

Stated concisely in more technical terms, terminal services is a Microsoft or Citrix technology that lets users remotely execute Windows-based applications on a terminal server (the central machine). Applications run entirely on that central server, which transfers only the user interface, keystrokes, and mouse movements between itself and the remote clients.

Throughout this article the generic name, *terminal services,* refers to this capability regardless of the vendor, Microsoft or Citrix. The Citrix approach provides a number of administrative advantages that Microsoft lacks, but both solutions will support multiple client sessions. Citrix's solution also costs more than Microsoft's.

Though simple to describe, terminal services prompt a flood of logistical questions. Are there collisions when multiple users open the same project? Does every user have access to all the data? How powerful does the central machine need to be if supporting a dozen simultaneous users? Thankfully, given terminal services' maturity in the mainstream information technology industry, the answers are readily available.

Humpty Dumpty Sat on a Firewall

Terminal services technologies are not particularly new. Citrix initially worked with Microsoft to create terminal services protocols beginning with Citrix's Independent Computing Architecture (ICA) protocol and, later, Microsoft's Remote Desktop Protocol to support applications such as NetMeeting. With this technology, a salesperson could visit a customer site and, sitting at the customer's computer, replace the local desktop with a terminal services view of the salesperson's remote computer. The salesperson could then demonstrate any programs already installed on his remote computer, or simply showcase the operating system itself. No need to bring a laptop; just use the customer's own Windows computer and an Internet connection to transmit the screenshots.

Microsoft initially deployed terminal services as single-session technology, meaning only one user at a time could access the remote computer. Much has changed since then. Terminal services now support connections between a Microsoft server and any other operating system's terminal. The word "independent" in the ICA protocol refers to its ability to serve, for example, X-terminal (UNIX) clients, Macintosh clients, Windows CE clients, and others. Furthermore, terminal services no longer have to replicate the entire desktop of the remote computer, as illustrated in Jane's ArcMap example. When running ArcMap at her hotel, Jane's laptop's local file system and all locally installed programs remained visible on her desktop while the terminal services view of ArcMap ran in its own self-contained space.

Perhaps most important, though, is that terminal services is no longer limited to single-session operation. In ESRI's benchmarks, 20 separate users all connect to the same, single, remote machine to run ArcMap. Allowing many people to use the same asset brings up an issue that isn't really technical at all: namely, how does the licensing work?

If the maximum number of users is 10 people, do you buy 10 licenses? In ESRI's case, the ArcGIS desktop uses the FlexLM license manager which works the same way in a terminal services implementation as in a desktop user session. So, in an office with 10 users, five floating ArcGIS desktop licenses could satisfy everyone if they're all willing to time-share. For instance, half could use ArcGIS in the morning, and the rest in the afternoon. If a sixth user tries to start an ArcMap session, he will get the message that no licenses are currently available. (ESRI is not giving away the store, of course. Users pay for flexibility: floating licenses cost more than single-use licenses.)

Adventures in Wonderland

Envisioning an office of multiple spatial users sharing one central system raises all sorts of questions about data, versions, performance, and cost. For instance, what happens if multiple users save a project with the same name? As ESRI's Dave Peters explained, "Each Citrix user has a unique user-defined profile based on their network logon, which can identify a separate and distinct user file storage workspace on the Citrix farm (usually located on a separate file server). Other users would only have access to a file in another workspace if that file is shared." As for common data mixing with private data, Peters noted, "Normally a user would not have access to another user's workspace, and shared data would be stored on a shared file server volume." In other words, each user can have a private storage area on the central system, but can also access any shared datasets. Ideally, in a multi-user environment, one shared data source is an ArcSDE database with geodatabase functionality, such as versioned editing. Because each user has a unique profile, the geodatabase can track who edited what, limiting conflict resolution and quality assurance to the discretion of a single administrator (rather than to chance and timing).

Using Citrix-based terminal services also opens up a unique, though seldom needed, capability: two or more people can open the same project at the same time. In Peters' words, "Citrix does have some shared session capabilities for joint collaboration, although this is a special shadow function capability, and users would need to be configured with appropriate permissions to use this functionality." So when collaborating, multiple users could share control of the mouse, for instance.

As for cost, ESRI licensing is the same as with workstation licensing, since it is based on floating licenses managed by a separate license manager. Thus, there is no additional ESRI cost for using Citrix Technology, though Citrix and Microsoft provide concurrent pricing for each of the user terminal sessions. Part of the economic picture should also include time savings. Instead of having to install many copies of a spatial application on each user's workstation, an administrator performs only one install on each Citrix server. Likewise, data management tasks, such as backups, take less effort with centralized, rather than distributed, data.

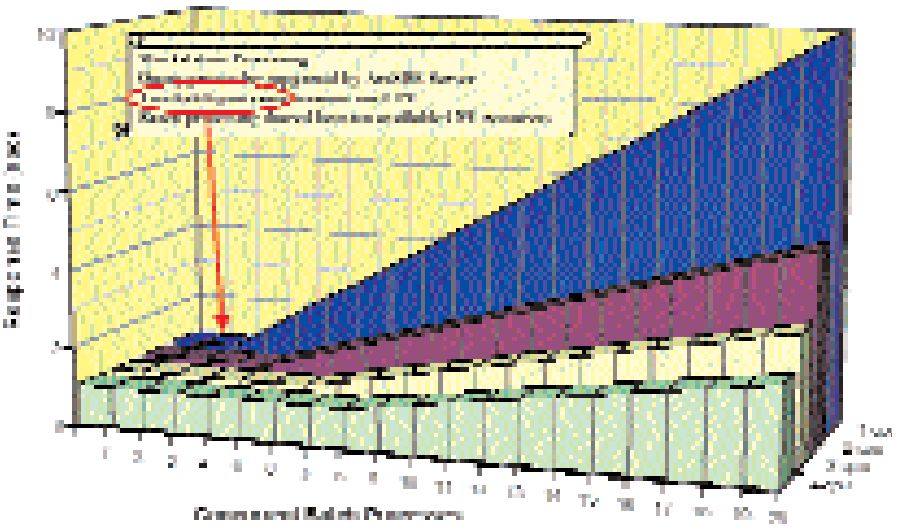

FIGURE 3 This image, created by ESRI's Dave Peters for a white paper on terminal services (available at www.esri.com/systemsint/kbase/strategies.html), diagrams performance of single and multiple CPU systems handling multiple users with terminal services delivery of ArcSDE data. The message: more CPUs prolong zippy performance with a growing collection of simultaneous users.

"'Time! Time!' Shrieked the Mad Hatter"

Most software evaluations put performance at the top their requirements list. Terminal services compete well in this regard. Among today's delivery methods, terminal services are the ultimate thin man. In an evolving white paper on system design strategies (see www.esri.com/ systemsint/kbase/strategies.html), Peters describes bandwidth requirements as follows: "The terminal display traffic requirements are very small, supporting full server application performance over 28-Kbps modem dial-up connections (displays with an image backdrop may require more bandwidth)."

As for the central server, performance is a result of power; more CPUs result in smaller performance degradations as more users share the machine. Peters diagrams performance on 1-, 2-, 3-, and 4-CPU machines as user loads grow. When configured properly, response time remains relatively constant as the number of users supported by the platform increases. As CPU use reaches the full capacity of the machine, users will start to experience degraded performance, meaning that each new user after that point slows down the response time for all users at a steady, predictable rate (see Figure 3). With properly configured and sized central servers, users usually experience better response times than what they can achieve with an equivalent workstation environment.

This (somewhat counterintuitive) performance boost is a result of shifting processing and data to a more powerful server machine capable of outperforming the laptop or workstation of most single users. Performance also improves in a terminal services setup if spatial data resides in an ArcSDE geodatabase accessible to the central server. ArcSDE uses such techniques as data compression and buffered reads to speed up performance.

Two Ways to Slay the Jabberwock

In addition to investigating these operational details, I couldn't shake a lingering question about the future: do we really need another online spatial delivery technology? We all know the answer, and it keeps many of us employed: we need new technology if it's better than what we've already got. So, are terminal services better? For certain situations, terminal services delivery of an ArcGIS user interface may very well be more efficient, faster to deploy, and, arguably, cheaper than building a custom browser-based spatial user interface from scratch. Coming immediately to mind as a good fit for such an approach are intranet-based applications with a pool of part-time users — quite a different animal than a public Internet-based spatial Web site.

To elaborate on the difference, we'll first compare the similarities. Who, by now, is unaware of the benefits so well-proven by successfully deployed Internet mapping applications spanning the spectrum of applications from America Online's (www.aol.com) MapQuest (www.mapquest.com) to the U.S. Census Bureau's (www.census.gov) American Fact Finder (http://factfinder.census.gov)? The same benefits apply equally well to mapping applications delivered by terminal services.

Both Internet mapping and terminal services confine spatial applications and data to a central computer, reducing network bandwidth requirements. The only remote piece is either an Internet browser or Citrix client. Administration and upgrades happen only on the central system — remote users only need free browsers or Citrix client software which come with their operating systems or are easily self-installed. In addition to being more manageable, centralized data are more secure than distributed data. The server can choose to deliver only images (Internet mapping) or only displays (terminal services) to the client devices. The actual data remains protected and isolated on the server.

So far, the comparison seems equal, without any special advantage of either delivery mechanism over the other. Both are also quite thin. The main difference is deployment. As a developer of Internet map services, I truly love designing spatial Web sites from scratch. Each customer has slightly different requirements, and crafting a cartographically legible, user-friendly, and performant solution can be a deeply satisfying art unto itself. As a businessperson, however, I have to admit that it takes much less time to strip away existing functionality from an already finished product than to build the same thing from scratch as a programmer.

Most custom spatial applications have the same navigation requirements plus two or three special analytical functions. Maybe planners need to measure the area of selected ecological zones, then make minor spatial edits. Or farmers need to list the crops grown in the past five years on selected land units. These applications, and many more like them, involve zooming and panning a bit, then performing a calculation. Suppose the requirement was intranet delivery of such an application to a dozen users. If you were the consultant, how would you proceed?

Chances are, ESRI's ArcGIS tools have the necessary functionality for these applications already built in. It doesn't take great skill to prune the ArcMap user interface such that the only remaining buttons or menu choices are those necessary to calculate and edit ecological polygon areas or to tally land-use histories. Certainly, pruning an existing set of tools is far less skills-intensive than writing each tool yourself. And when the user base is already experienced with GIS tools, why bother to reinvent the same interface when the original can be delivered, pruned or not, just as effectively via terminal services?

To be fair, maybe the choice of building a Web interface from scratch or implementing terminal services is not really as simple an equation as creativity versus deployment cost. The public are not GIS professionals and don't know their way around a professional GIS user interface, so offering them ArcMap via terminal services is seldom appropriate. In other words, as long as the public needs online maps, there will always be a need for custom browser-based Internet mapping interfaces. But, particularly in organizations with distributed office locations and professional GIS users, terminal services may eventually become the preferred option.