

Biographical Information

Jay A. Miller
Senior Architect
Level 3 Communications

Specific Responsibilities

Jay has been championing the use of GIS in support of various telecommunications Operational Support Systems for much of the last decade. As a Senior Architect at Level 3 Communications, he has led their internal GIS development team for the past 2 years. In that time he has incorporated GIS and spatial processing into Order Entry, Outside Plant Inventory, and Cable Protection systems.

Past Experience

A longtime advocate of GIS, Jay has developed spatial processing algorithms and spatial database structures for a GIS vendor, and has developed architectures for deploying GIS solutions into enterprise-wide, component-based systems. As distinguished engineer at an Outside Plant Information Systems vendor, he led the development of an automated mapping system for telecommunications networks.

Educational Information

BS – Mathematics, University of Maryland
MS – Applied Mathematics, University of Colorado

Employing GIS for Cable Protection Management

Jay A. Miller

Level 3 Communications

1025 Eldorado Blvd, Broomfield, CO 80021

Abstract

In this presentation, we examine the ways in which one telecommunications company uses GIS technology to help process the ever-increasing load of Call Before You Dig (CBYD) tickets. The system uses a combination of both geocoding, address validation, and outside-plant geospatial information to support automatic resolution of CYBD tickets. We will discuss the GIS tools and technologies employed in both this automatic and the manual ticket resolution processes.

Employing GIS for Cable Protection Management

Introduction - the problem of In-Ground Asset Protection

Anyone who has watched TV over the past decade has seen the public safety advertisements for “Call Before You Dig”. Many who have planted a tree in their backyard while ignoring this plea can speak to the embarrassment and expense resulting from this error of omission. Excavators have even more liability when digging or trenching, including the possibility of injury to equipment operators or area residents. After several fatal incidents resulting from rupturing high pressure gas lines or cutting high voltage electric cables, municipal and state governments established a system for determining the in-ground location of utility conduits.

This system consists of One Call Centers (OCCs) at the state and municipal level that collectively cover the United States and portions of Canada. Each OCC serves as a clearinghouse for requests to excavate in its region. For each request received the OCC will determine those utilities that are potentially affected by the excavation. This determination, while performed at a coarse scale of granularity, uses spatial processing to filter the set of affected utilities. Typically, the OCC uses a tiling based on TRS data to determine which utilities the excavation may affect. Utilities must supply spatial data describing their in-ground assets to the OCC for each region containing those assets. Each OCC will then determine the tiling coverage for that utility in its region.

When it receives an excavation request, the OCC will use this spatial data to determine which utilities to notify. The OCC issues a notification ticket to each such utility.

One Call Centers and their tickets

There is considerable variation in the format and form of the tickets issued by OCCs. This system was begun in the 1980s, long before the widespread adoption of the Internet standard digital communication channels (e.g. e-mail), and some OCCs have not adopted the current technologies. As a consequence, utilities must still accept tickets via fax and dedicated modem lines, as well as e-mail. The format of tickets varies as well. Some of the early digital solutions assumed that the receiver would use a Teletype terminal to print tickets as received; tickets from these sources still employ certain control characters, such as ctrl-G (the “Bell” character), to notify the receiver of the priority of an incoming ticket.

Despite the variation, all tickets contain the core information needed to process the request and determine the utility’s action. While nearly all tickets represent excavation requests, some tickets are requests from the OCC for information regarding the utilities handling of prior tickets. Such audit requests are distinctively indicated. Excavation request tickets all contain a ticket ID, the ID of the originating OCC, the excavating

party's contact information, the location of the excavation (typically a street address), and the priority of the ticket (emergency, short notice, or normal). Some tickets may contain additional information, such as geolocation coordinates (latitude, longitude) defining the excavation area.

Ticket priority is a very important component, as it determines timeliness requirements for the utility. Emergency tickets must be processed within two hours from receipt. This two-hour window includes the time to send a field engineer to locate and mark the in-ground assets, if needed. Short notice tickets typically require response within 24 hours, and normal tickets require response within 2 or 3 days, depending on the OCC mandates.

After analyzing and processing a ticket, the utility typically responds in one of two ways:

- Close the ticket as non-conflicting. The utility has determined that the excavation will not affect its in-ground assets.
- Dispatch a field service engineer to locate and mark the in-ground assets. The ticket will remain open, pending field location activity. When the field activity is complete, the ticket will be closed with a note that the field engineer marked the site.

Many OCCs request a confirmation of the disposition of each ticket sent to a utility. This confirmation is frequently referred to as "Positive Response". The positive response confirmations reflect the ticket's status: the utility can respond to an OCC that a ticket is non-conflicting, that a ticket is open pending field activity, or that a ticket is closed and the site has been marked.

Processing One Call Center Tickets

Level 3 Communications, as a utility, must provide ticket submission facilities to support every One Call Center in every state or municipality that contains a portion of our underground cable (Level 3's in-ground asset). In practice, this means that our ticket handling system, known as Sentinel, provides for fax receipt, e-mail receipt, and receipt via serial data line. Since none of these transmission paths are fail-safe, we record every ticket received as part of an audit trail. This enables Level 3 to verify receipt (or non-receipt) of tickets.

With a network that covers much of the United States, our utility must support over 40 One Call Centers. This means that the Sentinel system receives many different ticket formats. Upon receipt, our system determines the originating OCC and uses that information to drive the extraction of needed information from the ticket. As ticket formats are subject to change, we have implemented a script-driven ticket "parser" that can be adapted to new ticket formats by support personnel. As we mentioned earlier, the ticket is parsed to obtain needed data, such as excavator identification and contact information, OCC identification, location of the excavation site, and ticket priority.

Once the system has parsed the ticket, we attempt to determine the exact geo-location of the excavation site via a combination of data analysis and geocoding. The primary purpose for this geo-location is to automatically resolve the ticket as either non-conflicting or requiring a field engineer to visit the site and mark our underground cable

locations. It is important to note that this automatic resolution can have either of these two results.

An overall goal of the Sentinel system is to maximize the amount of tickets that can be resolved automatically. Level 3 Communications can receive as many as ten thousand excavation tickets in a single day. This load, combined with the need to resolve emergency priority tickets within two hours drives us to continually improve the automatic resolution process to increase the systems efficiency.

While we drive to maximize the number of tickets we can resolve automatically, we must keep the False Negative rate extremely small. A false negative from our system would resolve a ticket as non-conflicting when, in reality, our cable passes through the excavation site. While a puncture or cut of communications fiber will not endanger the life of the operators or nearby residents, the loss of communications capability and economic consequences can be severe, so it is important that we bias the system in favor of reducing false negative results at the expense of increasing false positive results. The optimal system will use all available geo-location information to keep false negatives close to zero while lowering false positives, since excavation site marking is an expensive and time consuming process.

To achieve this goal of accurately and automatically determining excavation/cable conflicts, we employ 3 sources of geo-location information. We have a geocoding/address validation service that provides latitude and longitude information from two independent landbase sources. By geocoding against both sources, we are able to detect when the sources disagree by a significant amount. If both sources agree, we place a high degree of confidence on the geocoded location of the site, hence a high degree of confidence in our subsequent determination of conflict. Given a high degree of confidence in a geocode location, we form a buffer polygon around that location and determine if this buffer intersects the buffer surrounding our network.

If there is no intersection, we automatically resolve the ticket as non-conflicting. If there is a significant overlap, we resolve the ticket as in-conflict, and begin the field dispatch process. Either outcome is a successful automatic resolution of the ticket. If there is a small amount of overlap, or if we are unable to determine the location of the site with a high degree of confidence, we place the ticket into a queue for manual resolution.

As we noted earlier several OCCs include geographic information in their tickets. This information typically takes one of two forms: a single point, or two points which indicate the diagonal of a bounding rectangle. While we currently do not use this information for ticket resolution, we have been researching ways to incorporate this information into our geo-processing to increase both the accuracy and efficiency of the automatic resolution process. With this additional information, we are exploring several enhancements to the algorithm:

- Build a polygonal site marker that incorporates both geocode points as well as any spatial information obtain from the ticket. One approach is to form the convex hull of this data and use the resultant polygon to build a site buffer. We will then

- use this buffer to determine conflict with the underground cable. This can cause problems if the geocode locations are distant from the ticket locations.
- Use the geocode information and the ticket information to verify accuracy. If the calculated geocode(s) fall within a small distance of the ticket location, we have a very high degree of confidence in the ticket data, and can use that for resolution. If the geocode(s) and the ticket disagree, we place the ticket in the manual queue, building site buffers from both the geocode results and the ticket location data.
 - Use a combination of the above – form the convex hull only if at least one geocode falls near the ticket location, otherwise use manual resolution.

Ticket Dispatch and Status

The manual resolution process involves the use of GIS presentation tools to display the geocoded site markers on a map along with the buffered cable route. The tools allow the operator to geocode other addresses, measure the distance between the site markers and the cable buffer, and determine the ticket conflict status. The Sentinel system is being enhanced to incorporate the site location data from the ticket into the manual process, to further aid the operator in their determination.

Once we have determined that a ticket is non-conflicting (either automatically or manually), the Sentinel system will notify the excavators of this determination. Sentinel will also provide a positive response notification to the originating OCC, if that OCC requires this confirmation. At this point the ticket is closed with a status of non-conflicting, along with audit data indicating when we informed the excavator and OCC of the ticket's resolution.

If the ticket has been determined to conflict with our cable network, Sentinel takes several actions:

1. Notify the excavator that the ticket is still open, and that a field engineer will be sent to mark the location of Level 3's cable at that site.
2. Create a dispatch work order for the appropriate field engineer to start the site marking process.
3. Notify the originating OCC of the status of this ticket (open pending on-site marking of cable), if the OCC requires positive response.

Sentinel provides a mechanism for the field engineer to respond that the site visit work order is complete. At this point we send a new notification to the excavator indicating that the site is marked. Sentinel will also notify OCCs of the change in ticket status as required.

Administering Cable Protection

The Sentinel system also incorporates GIS into its administrative functions. Sentinel's field service model is organized as a collection of divisions. Each division is further refined into regions, and each region into service areas. The service areas are defined

geographically; hence the Sentinel field service model is geographic. The administrator employs GIS tools to modify and refine service areas as our fiber network and markets change.

Conclusion

The use of GIS functionality is critical to Level 3 Communications' timely and accurate determination of conflict between excavation sites and our underground network. These determinations and subsequent activity are in turn critical to our success in providing high quality service to our customers.

The volume of requests the Sentinel system receives, along with the time constraints place on the system by some of the requests, necessitate the use of automatic resolution strategies. Our geolocation processing and spatial processing capabilities enable the system to meet the demands of both load and response time while enabling efficiencies in operation that have helped Level 3 Communications maintain a high-quality network.