Understanding the Utility Network: A Guide for Water Utilities

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Executive Summary

Water utilities today face a myriad of challenges ranging from increasing production demands, water shortages, aging infrastructure, and financing capital projects. In addition, utilities must also keep up with fast-paced changes in technology and information security.

To help address these challenges, Esri has developed next generation data structures and tools delivered via the ArcGIS® Utility Network Management extension to ArcGIS Enterprise, available at version 10.6 and higher. The utility network leverages ArcGIS Enterprise to create a seamless Web GIS. This system enables the sharing of your network across the entire organization, providing an authoritative view of your assets to everyone that needs it.

The utility network delivers advanced asset modeling capabilities, a modern web GIS architecture, and analysis tools that provide unprecedented levels of information gathering for better operational awareness and decision-making. The utility network also serves as a centralized system of record that can be accessed by everyone at the utility on any device at any time. This results in increased efficiencies in daily operations, planning projects, and responding to emergencies. The utility network can also be integrated with other business systems such as work order management and SCADA for a fully automated operational view in real time.

The utility network enables utilities to model the location of assets, including the modeling of internal configurations of complex assemblies such as pump houses, meter pits, and valve assemblies. The flow of resources through these complex assemblies is accounted for during network analysis, yet assets can also be hidden in map visualizations to declutter the operational view. Assets that control the flow of commodities, such as valves, can be modeled to reflect the directional flow of those commodities through pipes and depict what is happening in real time.

The utility network is designed to allow for new levels of specification in analysis such as identifying areas of water loss or determining valves to close in the event of a water main break. Assets and customers affected by outages can also be identified. Subnetwork management enables isolation of subsets in the network based on common attributes such as pressure. This drives additional analysis capabilities and visualizations of the network.

Network diagrams can be created from the utility network that provide a schematic view of network connections. These diagrams deliver a clear visualization of connectivity and relationships between features in the network that is not always apparent in a traditional map view.
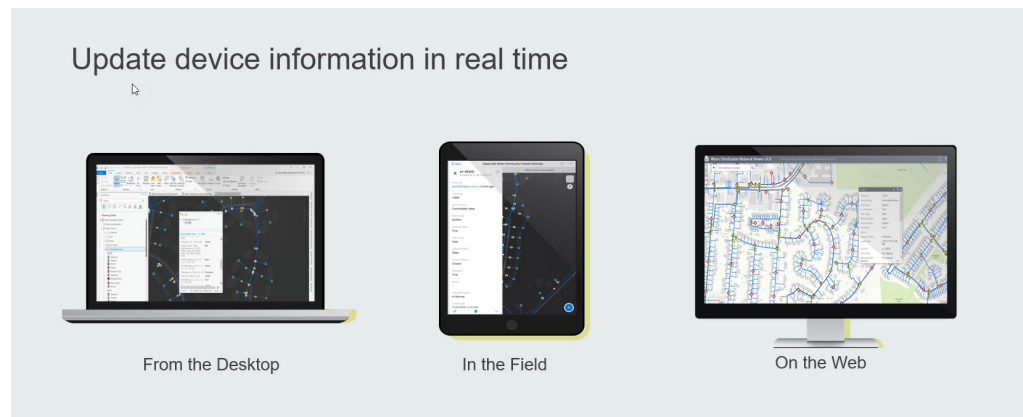
Benefits of the Utility Network

With the utility network, utilities can model, edit, and analyze assets across their organization. The utility network's capabilities are powered by a services-based architecture that makes data available on any device or web app.

The utility network provides analytical tools that give utilities actionable information for optimizing systems, cutting costs, and enabling them to do more with less, even in the face of aging infrastructure. Utilities can

- Access the utility network from any device.
- Model assets with greater detail.
- Perform analysis to make better decisions.

Access the utility network from any device

The utility network is accessible across the entire organization, providing network intelligence to anyone with access to the web. The utility network is available via web browsers, Esri apps, ArcGIS Pro, Esri partner solutions, and other clients. By taking advantage of the Web GIS pattern, edits to the utility network made in the office or in the field are immediately disseminated across the organization. This real-time transfer of information to and from the field greatly enhances efficiency and improves visibility of the overall operating picture.

Figure 1: Asset information in the utility network can be accessed and updated from any device, anywhere, anytime.

A common use case is the ability to get data into and out of the field in the event of a water main break. As field crews perform work and close valves, they can set the status of the valve to closed from a mobile device. The device's status is immediately visible to staff in the office, other field staff, or anyone using maps that contain network assets.

Model assets with greater detail

The utility network data model is designed to provide fast efficient data retrieval even with large datasets that contain highly detailed representations of assets in the real world.

With The ArcGIS Utility Network Management extension, utilities can model the connectivity between features that are geometrically coincident as well as features that are offset from each other. These connections between offset features enable optimized feature placement for display purposes. This also enables connectivity of features that are adjacent yet don't have a length of pipe connecting them such as adjoining features in a valve assembly.

While the utility network data model allows modeling features in greater detail, this can create cluttered and difficult to read map representations. The containment model solves this by enabling representations of dense features within a container. These features are only displayed when viewing this container. Examples include pump stations, meter pits, and valve assemblies.
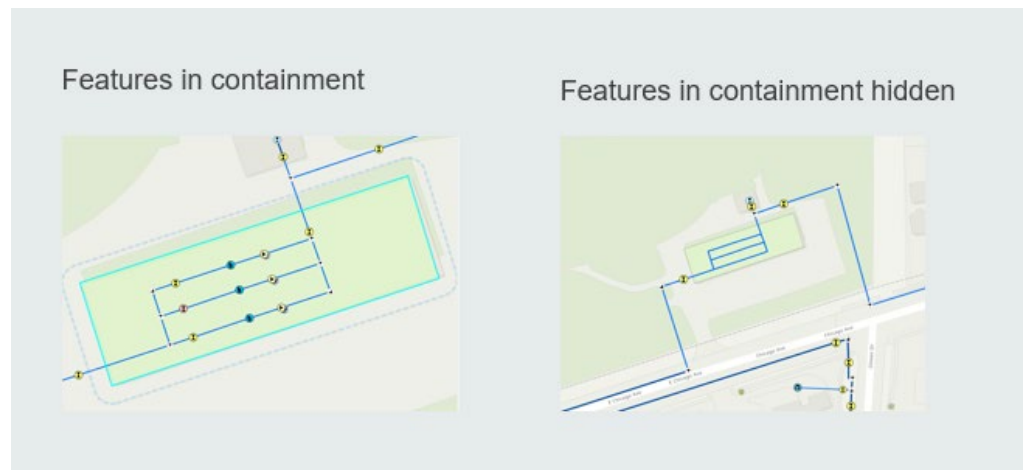
Figure 2: Features in containment can be hidden from view to declutter the map view.

A user-defined network rule base specifies exactly which type of features can be connected and associated with another. For example, certain types of fittings are only allowed in certain device assemblies. The network rule base for the utility network is referenced during editing operations to prevent the creation of incorrect connectivity and associations between features. Existing features that violate network rules are flagged on the map for correction. These are represented as error features. The creation of new features that do not adhere to network rules is not allowed.

The direction of the flow of resources through the network can be modeled using terminal connections on devices. This allows for more accurate modeling of network behavior and more powerful network analysis.

Attribute Rules

The utility network uses attribute rules to streamline the editing experience and improve data integrity. Attribute rules are user defined and can be used to autopopulate attribute values, prevent invalid edits, and perform quality assurance checks. Attribute rules are used in tandem with existing geodatabase rules such as domains and subtypes for cohesive editing results. Attribute rules are defined with ArcGIS Arcade scripting expressions. Arcade is a scripting language that can be used across the ArcGIS platform. To learn more about ArcGIS Arcade, see the ArcGIS Arcade web page.

Asset Packages

A utility network can be created and configured manually to meet a utility's asset management requirements, business demands, and modeling needs. However, this involves a high level of effort and familiarity with the utility network data model. To streamline the implementation of the utility network, Esri provides industry configurations for water distribution, sewer collection, and stormwater. Each configuration includes asset packages, maps, and applications configured for the specific industry. The asset packages provide an industry-specific utility network data model schema as well as asset classification, network rules, network definitions, and subnetwork properties for the utility network. The asset packages are delivered as file geodatabases and can be extended as needed. Removing features and fields from the asset package schema is not recommended as it may affect functionality built into Esri's ArcGIS Solutions for Water.

Solutions

ArcGIS Solutions for Water is a package of workflow templates consisting of maps, apps, and tools designed to get organizations up and running with a variety of common workflows shared by water utilities. Solutions for water utilities help improve operations and customer service, as well as maximize efficiencies. ArcGIS Solutions for Water can be downloaded from solutions.arcgis.com/#Water or deployed using the ArcGIS Pro Solution Deployment tool add-in (solutions.arcgis.com/shared/help/deployment-tool).

Perform analysis to make better decisions

The utility network includes advanced analysis tools that provide new levels of detail and visibility for network operations. Tracing analysis can identify the valves that need to be closed to isolate an area in the event of a water main break. Traditional upstream and downstream traces are also available to locate the source of flow or follow the path of resources downstream. The utility network includes a tracing framework for configuring detailed tracing analysis through geoprocessing.

Subnetworks

A utility network is a collection of subnetworks through which a commodity flows. Examples of subnetworks include pressure zones, district metering areas (DMAs), and sewer basins. Once subnetworks are defined, additional analysis can be performed such as identifying service connections, valves, and hydrants or adding the total length of water lines in a given pressure zone or DMA.

Subnetworks are dynamic and can be altered by the opening and closing of devices such as valves. A utility network uses the sources of the commodity to define the start points of a subnetwork and traces down to the ends (or sinks) of a subnetwork to discover its entire extent. When a valve is changed, the extent of a subnetwork can be recalculated. Devices that define the extent of resource flow within a subnetwork

are called subnetwork controllers. An example of a subnetwork controller that defines a pressure zone subnetwork could be a pressure reducing valve (PRV).
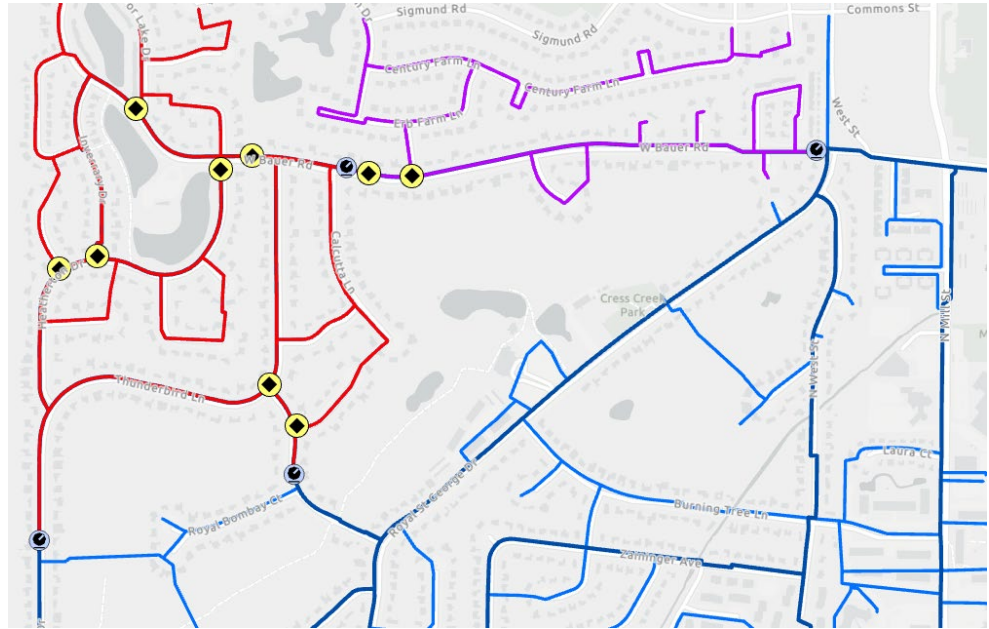

Figure 3: Subnetworks enable DMAs and asset inventories to be isolated and analyzed.

Network Diagrams

The utility network provides an integrated mechanism for creating and working with network diagrams. Network diagrams are a schematic view of the network that provides a symbolic representation of features and how they are connected. This functionality allows you to efficiently create multilevel representations, readily check network connectivity, and obtain logical views of the utility network. The ability to display network connectivity between features is the primary use of the network diagrams. Diagrams can also show the results of a tracing analysis.

Architectural Configuration of the Utility Network and Software Requirements

An ArcGIS Enterprise base deployment with an enterprise database is required to store the utility network. The enterprise database can be deployed in Oracle, SQL Server, SAP Hana, or PostgreSQL. The utility network is enabled by the ArcGIS Utility Network Management extension to ArcGIS Enterprise. The utility network is accessed through REST services that are published to ArcGIS Enterprise, where they can then be accessed and managed via ArcGIS Pro desktop software or in web maps via a web browser or mobile devices.
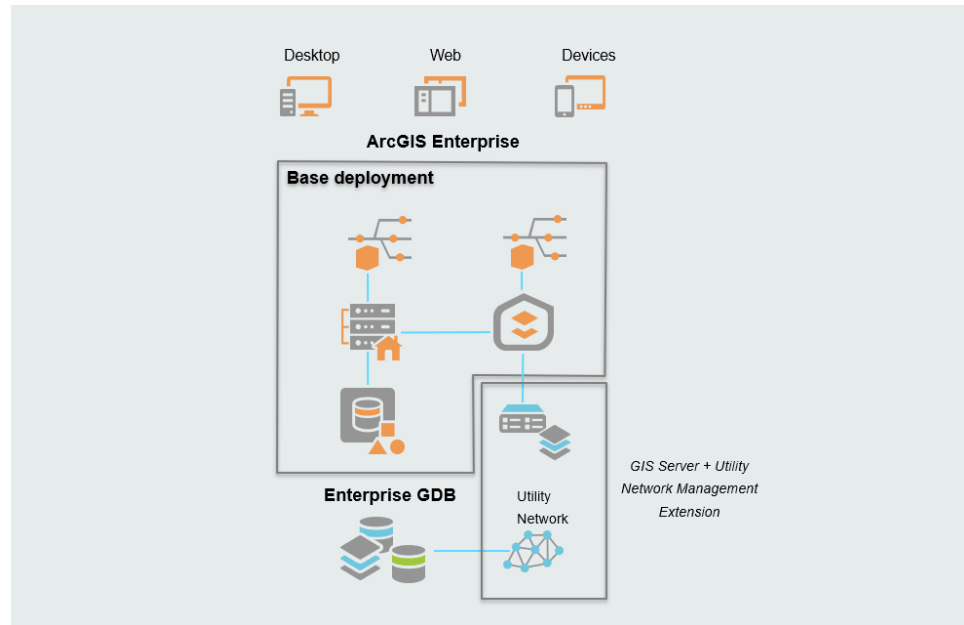
Figure 4: The ArcGIS Enterprise Base Deployment

Migrating to the Utility Network

There are several approaches to migrating existing features to ArcGIS Utility Network Careful consideration should be made using the steps in the next section depending on your utility's existing data, specifically, if you have implemented a geometric network and/or any of the existing Esri ArcGIS Solutions for Water. Esri has created a set of tools for migrating data that is currently in the Local Government Information Model. The migration tools utilize FME workbenches in either the ArcGIS Data Interoperability extension or Safe Software FME. Familiarity with these tools is critical for migration. It is recommended that you start with a small geographic area such as a pressure zone.

Planning for Migration

The most important thing to understand is that you should migrate your data to the ArcGIS Utility Network when the time is right for you and your organization. Esri has established a utility-specific release for ArcMap™ and is committed to supporting ArcMap 10.6.1 until at least 2024. Esri will also continue to support ArcMap and the geometric network at version 10.7 and beyond. If your organization updates to newer releases frequently, then you may not need to stay at the utility release. However, to be best prepared when the time is right, we suggest the following activities:

1 **Ensure existing data quality.**

The ArcGIS Utility Network may expose issues with your current data, particularly when it comes to connectivity. Therefore, we recommend performing rigorous data quality checks and data cleanup prior to migration. Doing so will make network implementation easier and give you higher-quality data now.

ArcGIS Solutions for Water includes tools and workflows for cleaning up your data using ArcMap and the ArcGIS Data Reviewer extension. For more information, please see the Data Reviewer for Water Utilities solution. To enhance your current data editing and analysis workflows, it may also be worth looking at the Water Geometric Network Editing and Analysis solution.

2 Document integrations with other business.

Your utility likely has many business systems, such as billing, computer maintenance management system (CMMS), and document management, that are either directly integrated with or depend on output from ArcGIS. We recommend identifying and documenting the following:

- Systems that are deployed on top of ArcGIS
- Third- party systems that integrate with ArcGIS
- Database views from third-party systems
- Workflows/Systems that require export from ArcGIS

3 Document configurations and customizations specific to your network data.

For example, if you have deployed any of the following:

- Editing and productivity tools including the Water Geometric Network Editing and Analysis or Data Reviewer for Water Utilities solutions

- Custom geometric network traces

- Database triggers

- Web or mobile apps consuming network data

It is important to understand current workflows and required functionality. There may be some gaps between what you are currently using and what is available with ArcGIS Pro and the ArcGIS Utility Network extension.

4 Evaluate Attribute Assistant methods.

If you currently use Attribute Assistant, you should document all the Attribute Assistant methods in your Dynamic Value table. This is important because again, there may be some gaps between what you can do now with the Attribute Assistant in ArcMap and what is currently available in ArcGIS Pro. If you are using Attribute Assistant, you should also start learning how to write expressions with ArcGIS Arcade. The primary replacement for Attribute Assistant functionality will be Attribute Rules written with Arcade expressions. When you are documenting your Attribute Assistant methods, be sure to capture both the workflow and the business reason for the workflow to determine if all are still valid. This may be a good opportunity to update some legacy workflows and eliminate unnecessary work.

5 Start using ArcGIS Pro.

If your organization or department has not started using ArcGIS Pro, now is the time! You will need to use ArcGIS Pro to create and administer ArcGIS Utility Network. ArcGIS Pro is also the primary client for editing and analysis of the utility network. There are many valuable resources to learn about ArcGIS Pro on the Esri Academy site, including the free web course Getting Started with ArcGIS Pro. Another great training resource is the Learn ArcGIS site.

6 Implement the current version of ArcGIS.

To create a utility network, you should use the current version of ArcGIS. We recommend that you create a development environment specifically for working with and understanding the utility network. This environment should be separate from your production GIS and can easily be set up in a virtual environment. This will enable you to provide hands-on learning of the utility network as well as testing prior to migration.

7 Deploy the ArcGIS Utility Network Configurations

These configurations make a generic network behave like a real-world resource network. Use the sample data and example workflows to become familiar with the utility network. For water utilities, network configurations are available for water, sewer, and stormwater networks.

Each ArcGIS Utility Network configuration includes the following:

- A data model supplied as an asset package
- Maps for network publishing, editing, and viewing
- Example workflows
- Sample data

It is not required that you use the Esri supplied asset packages to configure your utility network. However, because of the complexity of the networks, they are a good starting place. The asset packages can be extended, but we do not recommend removing or renaming existing components.

8 Determine the level of effort to migrate your data.

It is very important to understand the differences between your current data schema and the Esri supplied asset packages. Be sure to document any gaps between the two. Esri is providing sample workbenches for the Data Interoperability extension and FME to assist with migration. Additional migration tools are also planned for a future release.

9 Leverage Esri resources.

- Utility network help documentation
- Esri Academy
- Esri Consulting services

Additional Resources
esri.com/en-us/arcgis/products/arcgis-utility-network-management/resources

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