Evaluating impact of adding mobile capabilities to a foundational network information management system

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Introduction

This test study was designed and conducted to evaluate the impact of adding mobile capabilities to an existing foundational network information management system. The intent was to develop guidance for those considering expanding capabilities of a production system. The study was built upon the foundational network information management system configuration used in this test study, by adding both connected and disconnected mobile workloads. The system was hosted in Amazon Web Services (AWS) cloud infrastructure using AWS EC2 instances.

Note:

This test study is not intended to recommend a specific configuration. Rather, its purpose is to demonstrate how system tuning can enhance user experience and maximize return on investment. Adding or removing hardware or software resources without understanding their impact should be avoided.

- Learn more About test studies.

Tested workflows

This test study used workflows mirroring customer business processes. It conducted both connected and disconnected mobile workflows in conjunction with workflows for a Foundational network information management system to represent key activities required to maintain an as-built network. The workflows were conducted manually and through automated scripts to observe user experience and performance.

Foundational workflows

Foundational network information management workflows include those that editors and viewers perform to create, access, and maintain the as-built network. The following represent some of the foundational activities required to create, access, and maintain a gas network:

- Create a new service – adding a new customer gas service
- Remove a service – abandoning a customer gas service
- Extend a main – adding distribution pipe to the network
- Replace a main – modifying terminal connections for gas pipes
- View assets – displaying the location and condition of assets on a dashboard

- Query assets – locating and viewing assets

Mobile workflows

In network information management systems, connected and disconnected mobile workflows might also be employed in addition to the foundational workflows for data collection and field operations. In a connected environment, mobile workers can access real-time data with cellular connectivity. With disconnected workflows, mobile workers download an offline area and sync changes once reconnected. Offline map areas provide the ability to distribute a copy of mapping data on a mobile device (phone, tablet, laptop) so mobile workers can access this locally stored data even in places without internet connection. One key step of mobile workflows is to download an offline map area with bidirectional sync.

- Map viewing and editing – disconnected
- Network trace – connected
- View assets – connected and disconnected
- Query asset – connected and disconnected

Software

The system capabilities are delivered through the following software, deployed, and tested as part of this test study, at the listed versions with all available patches applied:

- ArcGIS Pro 3.3 (latest version here)
- ArcGIS Enterprise 11.3 (latest version here)
- ArcGIS FieldMaps 24.2.2
- ArcGIS License Manager 2024.0 (latest version here)
- ArcGIS Monitor 2023 (latest version here)
- ArcGIS Online
- SAP HANA 2.0 SPS 06 revision 63

Pre-testing

Pretesting is a step in our process meant to improve the results of our formal tests. Pretesting serves as an opportunity to:

- Identify system bottlenecks that could hinder the system's performance and usability under load
- Experiment with different settings and configurations in an iterative fashion
- Streamline the more formal load testing process

The initial physical architecture was nearly identical to a previously tested foundational network information management system configured with SAP HANA, with only the addition of an AWS Client VPN endpoint to allow mobile devices to connect. During pre-testing, we determined the system would not support the intended load with the additional workloads, shown below. The architecture was then appropriately adjusted, as described in the physical architecture. You can see the final test results after these modifications were made in the test results section.

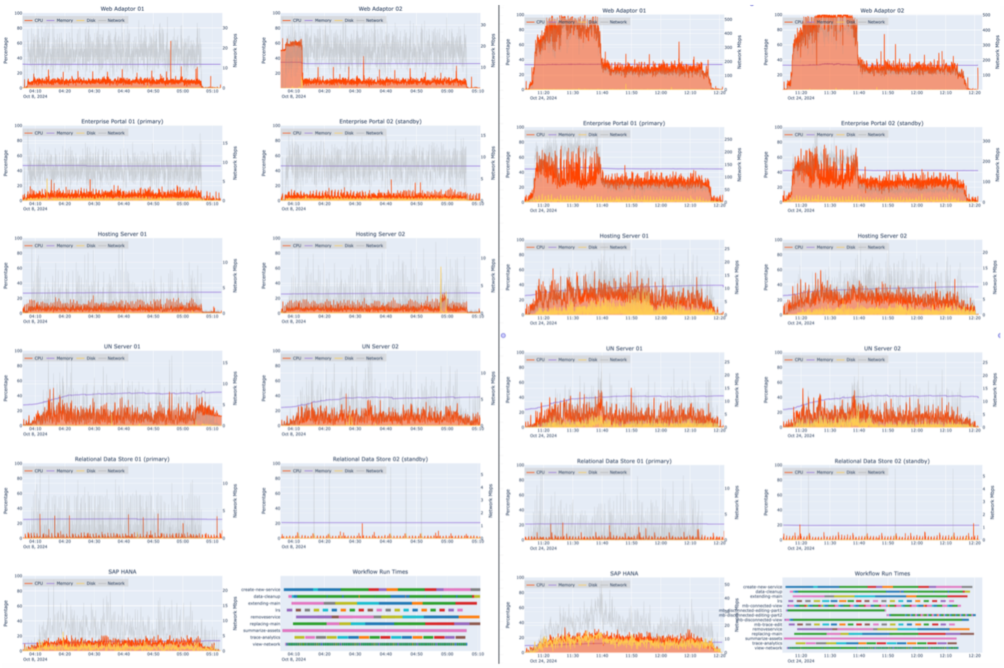
Note:

It is a good practice to test and validate your system whenever changes, like new workflows or increased workloads, are introduced to identify potential system impacts before they are introduced into a production environment.

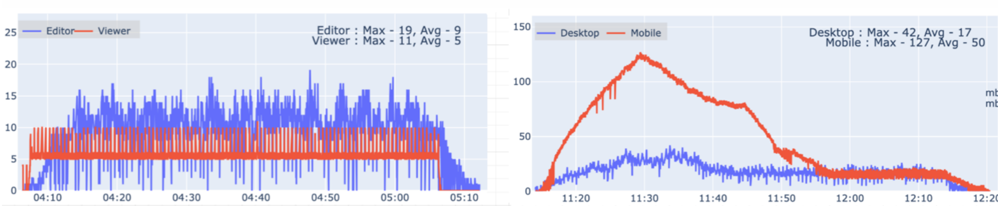
Pre-test at 4x design load

The system was first tested with foundational network information management workflows running without mobile workflows, shown on the left side of the figure below. With the exception of a spike in ArcGIS Web Adaptor 02 at the beginning of the test attributed to installation of Windows Defender updates, resource utilization is relatively low.

Compare that to the right side of the figure, which illustrates how adding mobile workflows on top of the 4x load causes significant CPU usage in the ArcGIS Web Adaptors and Portal for ArcGIS instances. The ArcGIS Web Adaptors are reaching saturation, which causes request processing to slow down or timeout. All four GIS servers and the database are also showing higher CPU (orange) and disk usage (gold). This is due to the download step in the offline workflows, where the 2.66 GB offline area is being downloaded by a large number of mobile workers.

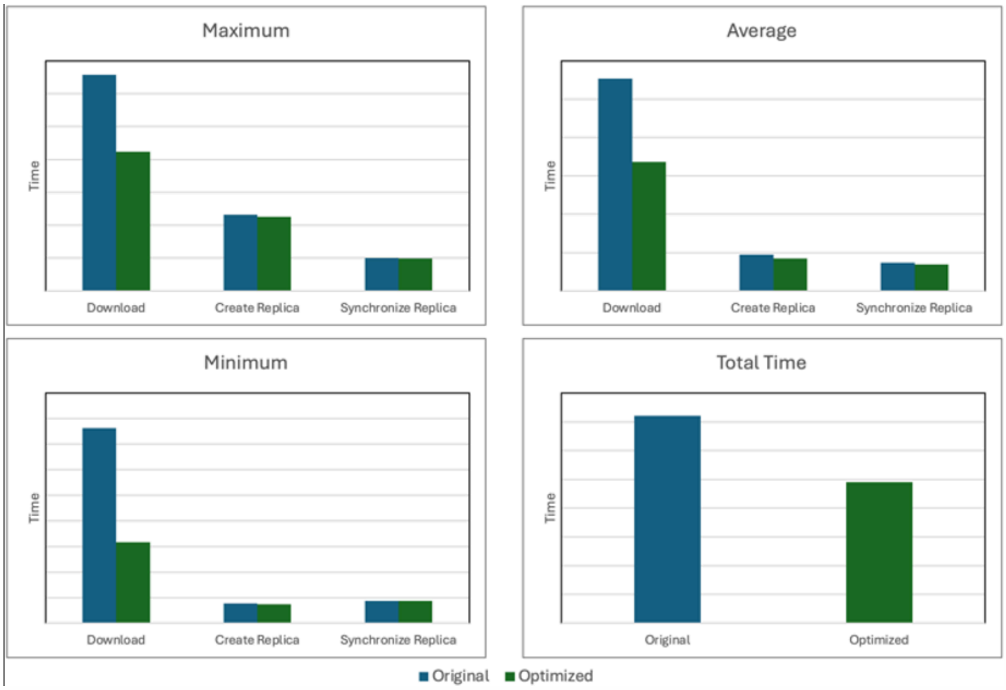


The open requests for the foundational load alone shown below (left side) illustrate the system handling the load. There is a small buildup of open requests early in the test that stabilizes with a maximum 19 editors and 11 viewers. However, when the additional mobile load is added (right side), requests ramp up to 42 desktop (viewers and editors) and 127 concurrent mobile requests before downloads are complete and the load drops off. This pattern indicates a slowdown during the download step of the test while users wait for the offline area download to complete.



Instance sizes

During pre-testing, we observed long download times for offline areas (2.66 GB in size) which were upwards of 30 minutes (see figure below). After some troubleshooting, we determined the issue stemmed from very high CPU usage on the ArcGIS Web Adaptor and Portal for ArcGIS instances, which was restricting throughput and causing downloads to timeout. To address this, ArcGIS Web Adaptor instances were increased from 2 vCPU to 8 vCPU and Portal for ArcGIS instances were increased from 4 vCPU to 8 vCPU.



The download step of disconnected workflows in particular benefitted from increased ArcGIS Web Adaptor and Portal for ArcGIS instance sizes, with the download time reduced by 41%. However, this is excess capacity when large numbers of downloads are not in progress. In a production environment, we would look for some way to scale those components during peak times and reduce instance sizes when not needed to reduce costs. Therefore, optimizing your resources while balancing the size of offline maps (making them as small as possible while covering the necessary area) is crucial to get the right balance of performance and cost.

- Learn more about Best practices for taking your maps offline.

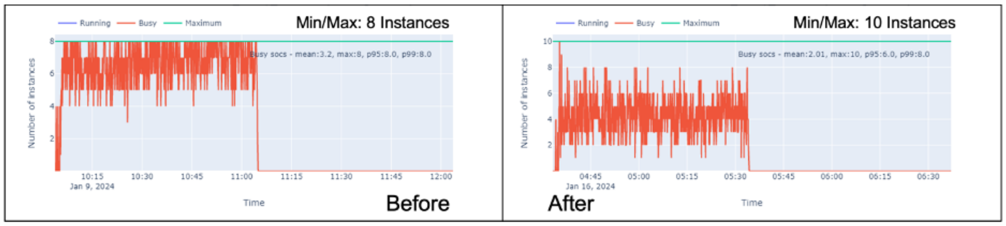
Service instance configuration

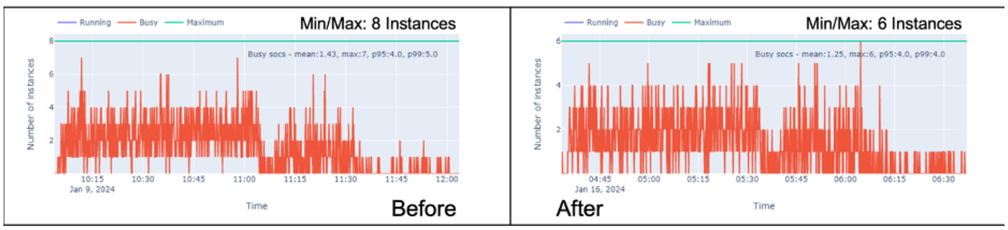
In ArcGIS Enterprise, service instances of a published service are called ArcSOC processes. There are different ways to configure ArcSOCs to avoid long wait times and poor user experience. In general, if the number of busy ArcSOCs exceeds the maximum assigned to a service, wait times will increase until an ArcSOC becomes available. However, if the maximum number of ArcSOCs across all services is greater than available vCPUs, wait times will also increase as all vCPUs become busy. Therefore, it is important to monitor and manage the ratio of ArcSOCs to available vCPUs, especially when system changes are introduced.

With 16 vCPUs available on the two hosting servers, the initial service instance settings for the mobile utility network service and the read-only gas utility network service were each set to the following:

- Minimum: 8
- Maximum: 8

Because the read-only gas utility network service ran at maximum ArcSOC usage throughout most of pre-testing while the mobile service had an excess of free ArcSOCs, we learned that some service reconfiguration was needed. See the figures below for a comparison of ArcSOC utilization before and after optimization .





Service instances for the mobile utility network service were decreased from a minimum and maximum of 8 to a minimum and maximum of 6. Service instances for the gas utility network service were increased from a minimum and maximum of 8 to a minimum and maximum of 10. After the change, the charts show a more even distribution between both services, and user wait times were measurably improved.

- Learn more about Tuning and configuring services
- Learn more about Configuring service instance settings

Pre-testing outcomes

Pre-testing the original foundational network information management system with the added mobile workloads helped to identify and correct system bottlenecks and misconfigurations that would have otherwise negatively impacted system performance and end user experience in a production environment. Our pre-tests resulted in the following system adjustments that were incorporated before performing the formal tests:

- The ArcGIS Web Adaptor instances was sized up from 2 vCPU to 8 vCPU.

- The Portal for ArcGIS instances were sized up from 4 vCPU to 8 vCPU.
- The size of the offline areas was optimized to make them as small as possible while covering the necessary area.
- The ArcSOC configuration was adjusted to provide a more even distribution of utilization and reduce wait times across both the mobile utility network service and gas utility network service.

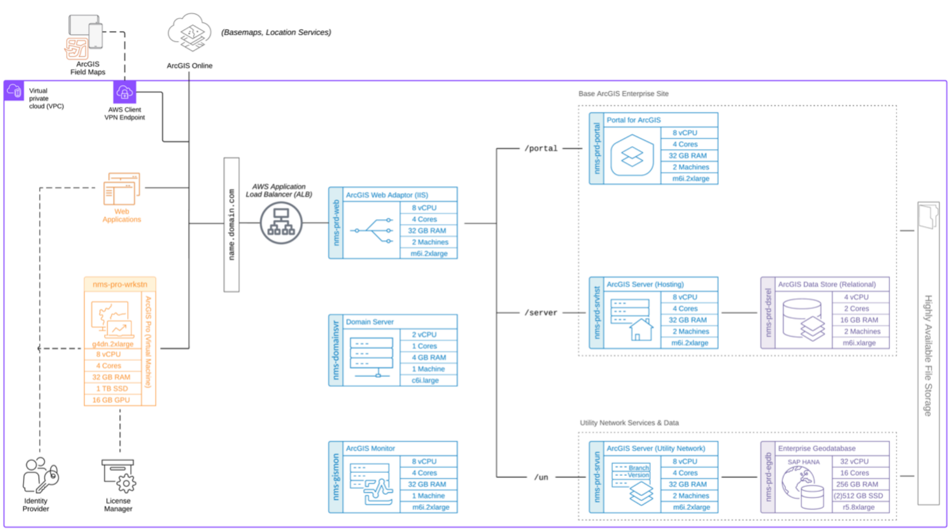
Physical architecture

To conduct formal testing, the following physical architecture was designed with:

- A small to medium-sized gas utility in mind
- Support for workflows with a target design load of 15 ArcGIS Pro editors, 200 ArcGIS web users (general user personas), and 200 mobile workers.
- An enterprise geodatabase configured on SAP HANA
- AWS cloud infrastructure

The following adjustments identified in pre-testing were made to the final physical architecture you can view below:

- The ArcGIS Web Adaptor instances was sized up from 2 vCPU to 8 vCPU.
- The Portal for ArcGIS instances were sized up from 4 vCPU to 8 vCPU.



The following represent the machine sizes chosen and validated for the scope and purpose of this test study. However, it is highly recommended to follow a complete design process to account for your business and technical requirements.

Desktop (ArcGIS Pro & web apps)

- 3 instances
- G4DN.2xlarge instance type
- 4 CPU (8 vCPU)
- 32 GB RAM
- 16 GB GPU
- 1 TB SSD Disk

ArcGIS Web Adaptor

- 2 instances
- M6i.2xlarge instance type
- 4 CPU (8 vCPU)
- 32 GB RAM
- 128 GB Disk

Portal for ArcGIS

- 2 instances
- M6i.2xlarge instance type
- 4 CPU (8 vCPU)
- 32 GB RAM
- 128 GB Disk

ArcGIS GIS Server

- 2 instances
- M6i.2xlarge instance type
- 4CPU (8 vCPU)
- 32 GB RAM
- 128 GB Disk

ArcGIS Server (hosting server)

- 2 instances
- M6i.2xlarge instance type
- 4CPU (8 vCPU)
- 32 GB RAM
- 128 GB Disk

ArcGIS Data Store (relational)

- 2 instances
- M6i.xlarge instance type
- 2 CPU (4 vCPU)
- 16 GB RAM
- 256 GB Disk

ArcGIS Monitor

- 1 instance
- M6i.2xlarge instance type
- 4 CPU (8 vCPU)
- 32 GB RAM
- 256 GB Disk

File storage

- 1 instance
- C6i.xlarge instance type
- 1 CPU (2 vCPU)
- 8 GB RAM
- 2 TB Disk

Database

- 1 machine

- R5.8xlarge instance type
- 16 CPU (32 vCPU)
- 256 GB RAM
- Two 512 GB Disks

Domain server

- 1 machine
- C6i.large instance type
- 1 CPU (2vCPU)
- 4 GB RAM
- 128 GB Disk

Additional design considerations

A virtual private network (VPN) was introduced to enable secure communications between mobile devices and the network information management system. In this design, the AWS Client VPN endpoint enables mobile devices to connect. The VPN can impact the performance and user experience, with latency being an inherent factor. For more information, see mobile app deployment. Additional approaches to enable external connection are detailed in the ArcGIS Secure Mobile Implementation Patterns technical paper.

Test results

After pre-testing, more formal testing was conducted to evaluate the modified architecture and configuration with the foundational and mobile workflows. The modified architecture was tested by adding mobile workflows at different loads, with desktop and editing workflows running consistently at 4x design load. Each component was monitored as the workflows were conducted against different load scenarios. You can compare the impacts in resources utilitization on the modified architecture as compared to the original.

Upon test completion, results were assembled and analyzed to validate the system as designed delivers positive end user experience and efficiency.

Workflow pacing

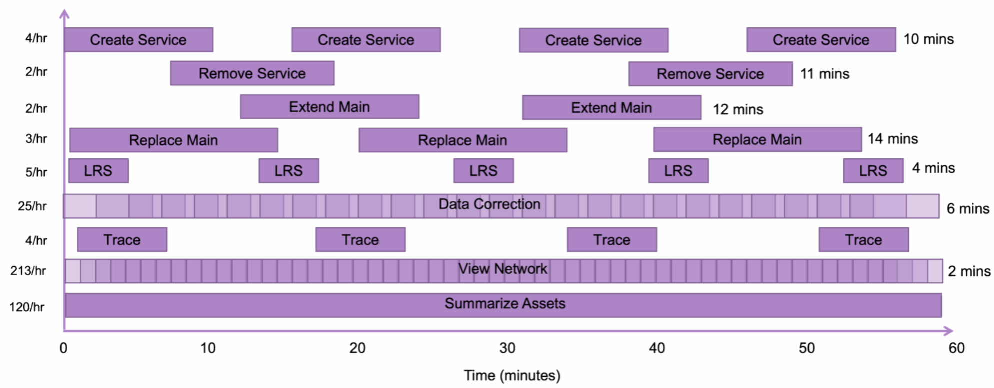
This test study applied a pacing model to the Tested workflows. A pacing model shows how the test intends to simulate the pace of work at a utility, where workflows are performed as some number of operations per hour across a team of staff resources. This approach was based on Esri customer input and aimed to match the small to medium gas utility customer scenario that the data was based on.

The workflows were staggered across a one-hour test period, while overlapping with each other as real-world workflows would. This overall breakdown of workflow pacing is considered the “design load” that the system is subjected to.

For this test, the web and desktop editing workflows were automated to run at four times the design load (4x) as shown in the figure below. Learn more about the Tested workflows.

No	Concurrent Workflows	Comment	Ops/Hr
	Create an As-built Network		
1	Perform Data Clean-up	This happens during initial migration (ArcGIS Pro)	100
	Access As-built Network		
2	View Network	Web viewers looking at individual assets	852
3	Summarize Assets	A dashboard that refreshes every 30 seconds	480
4	Trace Analytics	ArcGIS Pro users running a trace	16
	Maintain an As-built Network		
5	Create a New Service	ArcGIS Pro editing workflow	16
6	Remove a Service	ArcGIS Pro editing workflow	8
7	Extending a Main	ArcGIS Pro editing workflow	8
8	Replace a Main	ArcGIS Pro editing workflow	12
9	LRS for pipeline transmission	ArcGIS Pro editing workflow	20
	Total		1512

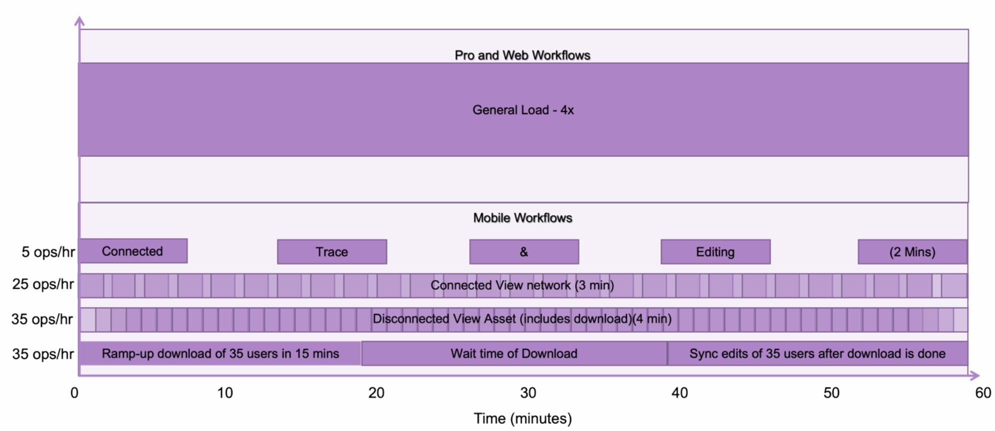
The foundational workflows were conducted according to a pacing model that is intended to mimic how people work, making the test more realistic. In this model, workflows are offset so they don't start or finish at the same time.



Mobile workflows were conducted while the system was under the load as described above. Design load for mobile workflows is shown below, at a total of 405 operations per hour. The mobile load was then multiplied while keeping desktop load consistent.

No	Concurrent Workflows	Comment	Users	Ops/User	Ops/Hr
	Access As-built Network				
1	Connected View	Mobile Workers looking at individual assets	25	4 view	100
2	Disconnected View	Mobile Workers looking at individual assets offline	35	1 view	35
	Maintain an As-built Network				
3	Connected Trace & Edit	Mobile Workers running trace and adding an asset	5	1 Trace + 1 Edit	10
4	Disconnected Edit	Mobile Workers	35	1 Download + 3 Edits	140
	Total		100		405

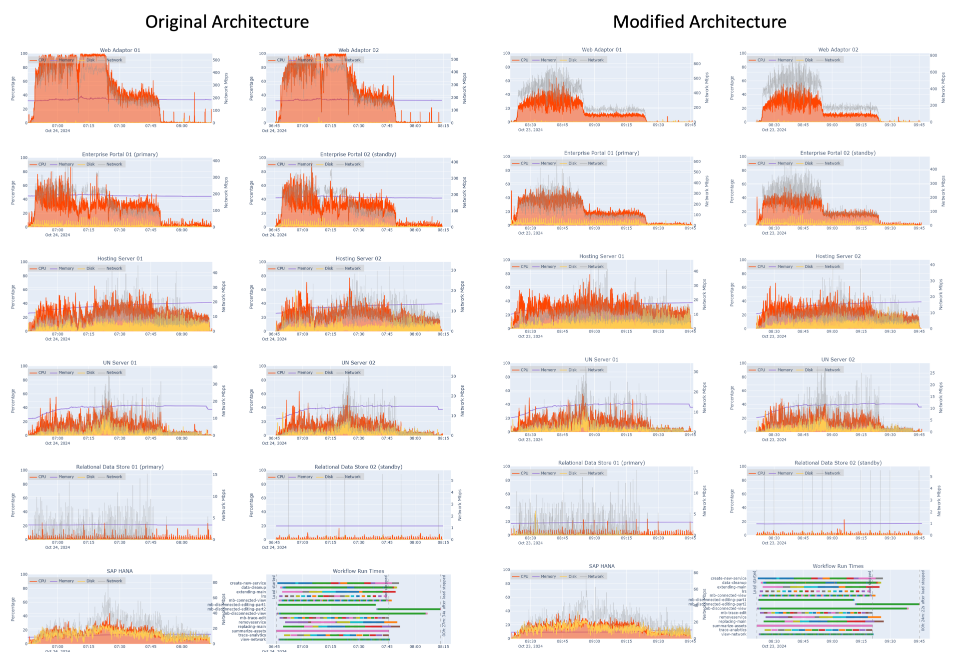
This pacing model shows the general load running at 4x with the mobile workflows paced at design load. The model adjusts as more load is applied to the mobile workflows.



The disconnected view workflow includes a download and a sync, which impacts ArcGIS Enterprise. The disconnected edit workflow starts with a similar download and sync, but also includes a second sync to upload changes. The work performed on the mobile device to view or edit data does not impact ArcGIS Enterprise.

Test scenario: 6x design load

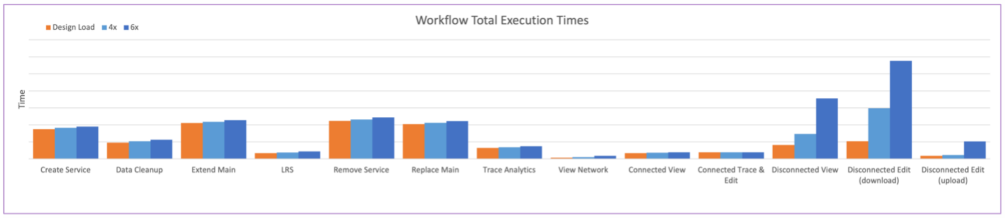
At 6x design load in the original architecture (left), the ArcGIS Web Adaptors are extremely saturated and Portal for ArcGIS machines are showing very high CPU usage (see figure 13). Compare this to the modified architecture (right), where resource utilization, especially at the ArcGIS Web Adaptor and ArcGIS Portal tiers, noticeably drops to more optimal thresholds. Additionally, you can observe how the increased vCPU in the modified architecture helped to reduce the network throughput (gray) restriction that we were seeing in the original architecture that was causing downloads to timeout.



User experience

As expected, user experience degrades with increased load. However, the effects are most noticeable with disconnected workflows, as shown below. For example, the disconnected view time, which includes the download step, increases by 44% between design load and 4x, and increases 78% between 4x and 6x. Most of that time would be attributed to downloading the offline area and synchronizing data. Therefore, aside from resource sizing, optimizing offline areas, providing mobile workers with good connections, and even staggering the downloads could help improve those times.

Conducted ArcGIS Pro workflow time degrades an average of 12% between design load and 6x, meaning editors are losing 58 minutes per day of time waiting for the system. Between design load and 4x, this number is 9%, or 43 minutes.



Since editors maintain the as-built network that many staff use for their work, it is important to provide a performant editing environment. Although adding the mobile workflows' load did not measurably impact the system until 4x the design load, user experience indicates configuration adjustments might be appropriate as loads begin to exceed the original design load.

The following may improve user experience and lead to an increased return on investment:

- Alternative load balancers
- Additional workload separation
- Increased instance sizes
- A secure mobile deployment approach. Learn more in the ArcGIS Secure Mobile Implementation technical paper.

Conclusions and key takeaways

This test study demonstrates how a network information management system's architecture can be modified to accommodate mobile workflows and provide needed business capabilities. However, it is important to test, observe, and then adjust the system as needed to support the intended workflows and loads. The goal is to make informed hardware choices that mitigate infrastructure expenses and operational costs, while striving for a positive user experience and maximum productivity. Productivity leads to a better return on investment, so focusing on user experience, as this test study does, will help you make decisions that can improve the bottom line.

Key takeaways

1. Adding mobile capabilities to any business focused system requires careful planning and testing to ensure optimal performance and user experience.
2. When adding new workloads to a system, good testing and observability practices are crucial in the build phase to determine whether system adjustments, like resizing instances or reconfiguring ArcSOCs, are warranted.
3. Downloading offline areas can be time consuming. Strategies are needed to mitigate this, and might include network, instance size, and map configuration adjustments.
4. The download step of disconnected workflows in particular benefitted from a larger instance size, with the download time reduced by 41%.
5. Optimizing your resources while balancing the size of offline maps (making them as small as possible while covering the necessary area) is crucial.
6. VPNs provide secure connections but may introduce latency, which can impact real-time workflows.
7. Validate your system whenever changes are introduced.