



Image from NASA:
https://commons.wikimedia.org/wiki/File:Earth_Western_Hemisphere_transparent_background.png#filelinks

Client-Side Web GIS

Introduction



Welcome to this web GIS course focused on client-side technologies and methods. In this first section, I provide a general overview of how the web works and introduce web mapping in the ArcGIS Online environment.

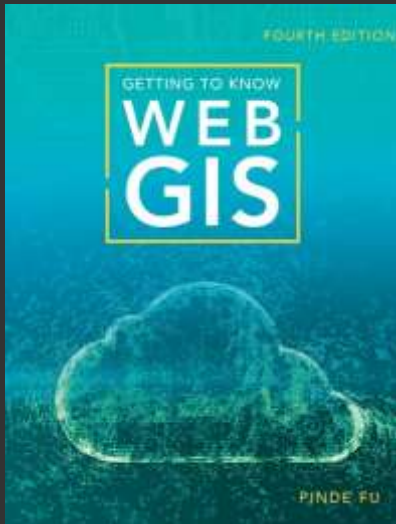
Module Topics



1. Client-Server architecture
2. Web languages
3. URLs, IP addresses, and ports
4. ArcGIS Online
5. App creation tools
6. ArcGIS Enterprise
7. Open-source web GIS tools
8. Accessibility

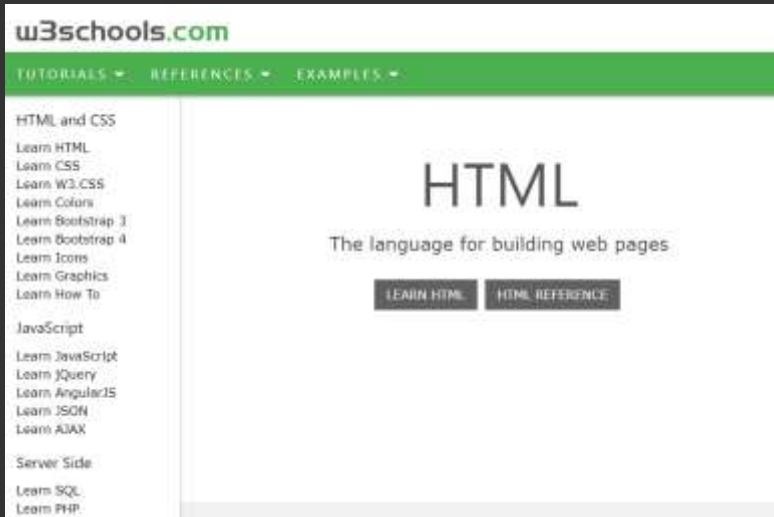
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These are the topics covered in this module.



<https://www.esri.com/en-us/esri-press/browse/getting-to-know-web-gis-fourth-edition>

Before we get started, I wanted to provide some recommendations and links to additional resources. If you are interested in learning more about ArcGIS Online, I would recommend the “Getting to Know Web GIS” text by Fu.



<https://www.w3schools.com/>

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If you are interested in learning languages for web development and web GIS, I would recommend w3schools.com.



<https://www.oreilly.com/library/view/html-css/9781118206911/>



<https://www.oreilly.com/library/view/javascript-and-jquery/9781118531648/>



<https://www.wiley.com/education/9781119149217>

This book series is a great resource if you want to learn web development.

- ❖ **Introduction to web programming for GIS applications:**
<https://www.udemy.com/course/introduction-to-web-programming-for-gis-applications/>
- ❖ **Server-side web GIS applications with Leaflet and PostGIS:**
<https://www.udemy.com/course/server-side-web-gis-applications-with-leaflet-and-postgis/>
- ❖ **Mobile GIS data collection apps with Leaflet and PostGIS:**
<https://www.udemy.com/course/mobile-gis-data-collection-apps-with-leaflet-and-postgis/>

Udemy also has some great courses relating to web development and web GIS.

How the Web Works

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Let's get started by exploring how the web works.

- ❖ **Server** = provider of resources or services
- ❖ **Client** = requester of services
- ❖ Multiple clients can connect to one server
- ❖ Internet allows these connections

The internet consists of computers and other devices that are connected remotely to form a network.

Within this network, servers provide resources and services while clients request these services.

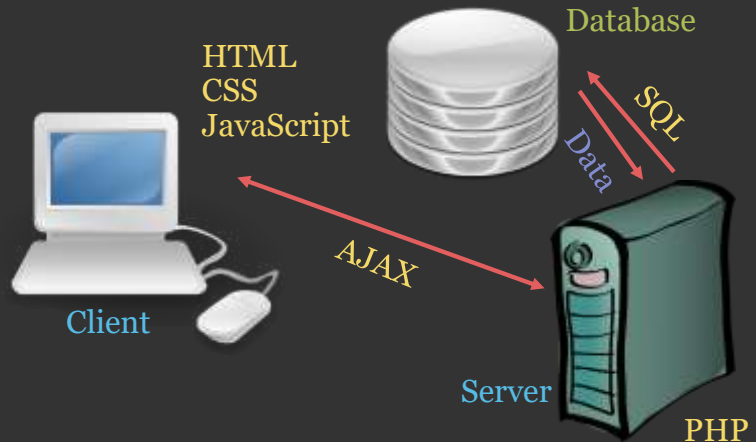
It is possible for multiple clients to access or connect to one server using the internet.

In order to transfer information and perform tasks, protocols have been established for standardization.

Client-Server Architecture



- ❖ **Client** = computers, tablets, phones, etc.
- ❖ Multiple **clients** can interact with one **server**
- ❖ **Client** requests data from **server**
- ❖ **Server** processes request and returns result
- ❖ **Client** does something with result



<https://commons.wikimedia.org/wiki/File:Oxygen480-places-server-database.svg>

https://commons.wikimedia.org/wiki/File:Scribley_PC_c_lip_art.png

By OpenClipart - OpenClipart, CCo,
<https://commons.wikimedia.org/w/index.php?curid=721320>

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Client devices are those that request information from a server and can then do something with this information, such as render a webpage or view data from a database. Client devices include personal computers, tablets, phones, etc. Multiple clients can request data from the same server simultaneously.

Servers process requests from clients and return information, such as the information needed to render a webpage or data from a database.

A variety of computer languages are used on the client device, generally termed client-side technologies. These include hypertext markup language (HTML), cascading style sheets (CSS), and JavaScript.

It is common for different technologies and languages to be used on the server-side. For example, structured query language (SQL) can be used to access data from a database.

Although we commonly think of clients and servers as computers, they are really software, as a traditional desktop computer can act as a server with the correct software installed.



❖ **HTML (Hypertext Markup Language)** = used to create the basic structure and content of a webpage

<https://www.w3schools.com/html/default.asp>

❖ **CSS (Cascading Style Sheets)** = used to design the webpage (where everything is placed and how it looks)

<https://www.w3schools.com/css/default.asp>

❖ **JavaScript** = define the interactive elements of a webpage that helps to engage the users

<https://www.w3schools.com/js/default.asp>

Hypertext Markup Language (HTML) is used to define or build the content of a webpage. For example, it is used to define text, images, lists, links, and additional content on a webpage. Currently, we are using HTML5, the most recent iteration of the language.

Cascading Style Sheets (CSS) are used to define the styling of the webpage, such as fonts, font size, colors, and layout. It is also used for responsive web design, which entails the layout of the page changing based on the screen size. This is how a website can function on screens of variable sizes. Given the wide variety of devices we currently use to access web content, this is extremely important.

JavaScript is a programming language that allows for interactive content. For example, clicking a button on a webpage causes something to happen, such as data from a form being uploaded or the page content changing. JavaScript is also used to generate interactive web maps (for example, the ArcGIS Maps SDK for JavaScript and the Leaflet JavaScript API). APIs will be explained in a later slide.

In this course, we will primarily focus on client-side technologies.

- ❖ **AJAX = Asynchronous JavaScript And XML**
- ❖ Allows web pages to be updated asynchronously by exchanging data with a web server
- ❖ Makes it possible to update parts of a page without reloading the whole page

https://www.w3schools.com/whatis/whatis_ajax.asp

Asynchronous JavaScript and XML (AJAX) technology allows for data to be read from a server after a webpage has loaded, updating a webpage without reloading the page, and sending data to a web server in the background.

This is very useful since it would be very inefficient and slow to reload an entire page every time something changes on the page.



- ❖ **PHP (PHP: Hypertext Preprocessor)** = server-side scripting language that is free and executed on the server.
- ❖ Generate dynamic page content
- ❖ Create, open, read, write, delete, and close files on server
- ❖ Collect form data
- ❖ Send and receive cookies
- ❖ Add, delete, and modify data in a database
- ❖ Control user access
- ❖ Encrypt data

<https://www.w3schools.com/PHP/DEfaULT.asP>

Different computer languages are used for server-side programming. One example is PHP: Hypertext Preprocessor. This language allow for many task to be performed by the server in response to a request from the client.

In this class, we will not cover server-side technologies. I just wanted to mention some examples here so that you are aware.

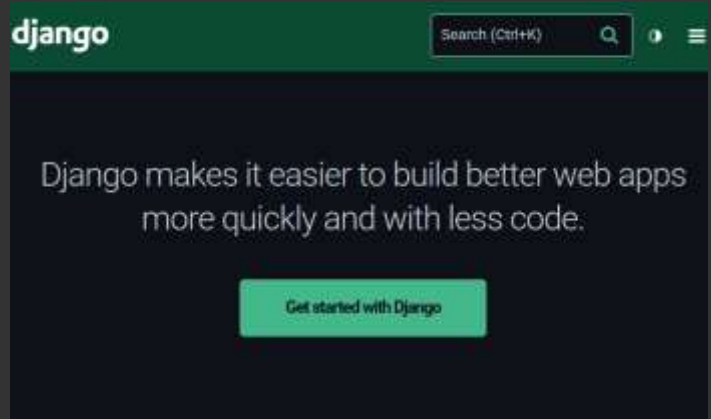
- ❖ Node.js = Run JavaScript on the server
- ❖ Generate dynamic page content
- ❖ Create open, read, write, delete, and close files on the server
- ❖ Collect form data
- ❖ Add, delete, modify data in your database

<https://www.w3schools.com/nodejs/default.asp>

Node.js allows for JavaScript to be used on the server to perform server-side operations and tasks.

❖ Django = Python framework for web development
<https://www.djangoproject.com/>

❖ Includes a module for working with spatial data ([geodjango](#))



Django is a Python framework for web development. Since many geospatial professionals use Python for geoprocessing and data analysis, Django may be worth considering for server-side development. There is also a module, [geodjango](#), that allows for working with spatial data.



❖ **SQL (Structure Query Language)** = allows you to access and manipulate databases

- ❖ Execute queries against databases
- ❖ Retrieve data from a database
- ❖ Insert records into a database
- ❖ Update records in a database
- ❖ Create new databases
- ❖ Create new tables in a database
- ❖ Create stored procedures in a database
- ❖ Create views in a database
- ❖ Set permissions on tables, procedures, and views

<https://www.w3schools.com/sql/>

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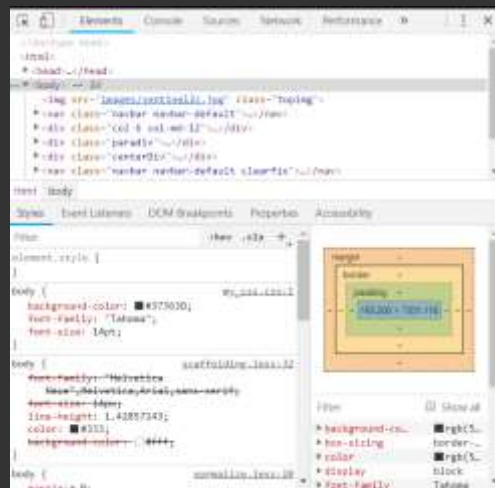
Structured Query Language (SQL) allows us to interact with databases. For example, the client can request information, and the server can process this request by submitting an SQL query to a database and then returning the requested information. For example, a query could be submitted to make sure that the item you want to purchase from an online retailer is in stock.

SQL is used for many database-related tasks, as demonstrated by the examples provided on this slide.

◀▶ The DOM



- ❖ **DOM = Document Object Model**
- ❖ **HTML** is parsed by the browser to create the **DOM**
- ❖ Attempt to convert the structure and content of the **HTML** document into an object model represented as a node tree
- ❖ Browser uses this model to render the webpage



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A web browser (Chrome, Firefox, Edge, Internet Explorer, Safari, etc.) is able to receive information from a server (for example, HTML, CSS, and JavaScript) to render a webpage.

To complete this task, the browser will need to generate a Document Object Model (DOM) from the data. I like to think of this as diagramming a sentence. The HTML is converted into a node tree to represent the components of the page and their interrelationships. This model is then rendered to generate the page.

You can think of this as the process of creating a conceptual model from the code that is used to render the actual page. If there is an error in the code, then the DOM may not be generated as intended, which can result in problems with the webpage.

Later in this course, we will use JavaScript to manipulate the DOM and change the page content or styling.

❖ **URL (Uniform Resource Locator)** = address for things on the web

<http://www.wvgis.wvu.edu/lidar/>

❖ **Protocol** = declares how your web browser should communicate with a web server

- **HTTP (Hypertext Transfer Protocol)**
- **FTP (File Transfer Protocol)**
- **Etc.**

❖ **Domain Name** = identifies a website

❖ **Path** = file or directory on the web server

A URL (Uniform Resource Locator) acts as an address for a specific page or content available on the internet, and it consists of several components.

First, a protocol must be defined. For example, HTTP (Hypertext Transfer Protocol) is used to transfer HTML content while FTP (File Transfer Protocol) is used to access and transfer files.

Next, a domain name is provided. For example, wvview.org or wvgis.wvu.edu.

Finally, a path can be provided for a specific page within the domain. For example, http://www.wvview.org/Prof_Maxwell.html.

On a server, a webpage is generally defined by a folder with the main page or landing page named index.html. The subsequent pages will occur within the folder. For example, on the West Virginia View webpage the main page is named index.html while my webpage is named Prof_Maxwell.html.

- ❖ **HTTPS = Hypertext Transfer Protocol Secure**
- ❖ Web browser encrypts any information you provide so it can't be understood by a party that intercepts it
- ❖ **HTTPS** is used when sensitive information is transferred or entered

In contrast to HTTP, HTTPS (Hypertext Transfer Protocol Secure) allows for data encryption to protect sensitive data.

Data are encrypted for transfer as opposed to being submitted as plain text that can be interpreted if intercepted.

In order to make a site secure using HTTPS, you will need to purchase a certificate and set up an SSL (Secure Sockets Layer).



- ❖ IP Address = Internet Protocol Address
- ❖ Numeric label assigned to each device connected to a computer network
- ❖ Network ID = network that the device is part of
- ❖ Host ID = designates specific device

An IP (Internet Protocol) address provides a unique, numeric address for each client or server connected to the internet. IPs can also be used to identify a device on a local network, such as a university domain, business domain, or home network.

The IP address consists of the Network ID, which indicates the network that the device is part of, and the host ID, which designates the specific computer or device.

For example, all devices on your home network will have the same Network ID but different host IDs.

Using a Domain Name System (DNS) allows you to provide a URL as opposed to an IP address to access a website.

Dynamic IP addresses are often used. This entails assigning host IDs to devices dynamically within the network when they are requested. So, each device in the network will not maintain a consistent host ID.

LAN (Local Area Network) is used to define a local network, such as that for a single business or home while WAN (Wide Area Network) is used to define larger networks, such as those maintained by internet service providers.

- ❖ Servers make services available to the Internet using numbered ports
- ❖ Separate ports will be used for different services
- ❖ Clients connect to a service at a specific IP address and a specific port
- ❖ IP Address + Port defines address of a particular service on a particular system

Ports identify specific addresses for applications and services provided by a server.

For example, a port can be defined to provide licensing credentials for software in the case of a license server. A client computer that needs to access the license would need to do so using the appropriate IP address and port for the server that is hosting it.

The server will listen for requests coming in through the port.

Note that it is generally not a good idea or impossible to use the same port number for multiple tasks, such as to license multiple pieces of software. Fortunately, multiple port numbers are generally available for a single server.



- ❖ **API = Application Programming Interface**
- ❖ Allow software to interact with each other
- ❖ Provide code, functions, and classes that can be used to complete a task on the web

```
<link rel="stylesheet"
href="https://unpkg.com/leaflet@1.9.4/dist/leaflet.css"
integrity="sha256-p4NxAoJBhIIN+hmNHzRCf9tD/miZyoHS5obTRR9BMY="
crossorigin="" />

<script src="https://unpkg.com/leaflet@1.9.4/dist/leaflet.js"
integrity="sha256-20nQCchB9co0qIjJZRGuk2/Z9VM+kNiyxNV1lvTlZBo="
crossorigin=""></script>
```

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An Application Programming Interface (API) is a set of rules, functions, and tools that allows one piece of software to interact with another.

APIs provide predefined code and procedures that developers can use to perform specific tasks without needing to write the underlying functionality from scratch.

For example, the Leaflet JavaScript API provides functions and classes that allow developers to create interactive web maps.

APIs have many uses and can be thought of as libraries of code and tools that allow programs to access data, process information, or generate content.

In this course, we will primarily interact with APIs used for web mapping and interactive map production.

Websites that emphasize:

- ❖ User-generated content
- ❖ Usability (ease of use, even by non-experts)
- ❖ Interoperability (this means that a website can work well with other products, systems, and devices) for end users

Web 2.0 is the concept of making the web user-friendly for compatibility and the production of user-generated content.

As GIS professionals, we have embraced this concept to create interactive web maps and make our data and maps more accessible.

Wanted Sighting Report

1. Enter Information



Subject Sighted (required)

Select...

Description of Sighting

Date Sighted

Date Reported

Your Name

Your Phone Number

Attachment

Select File

- ❖ Allows users to edit geospatial data using a mobile or web interface
- ❖ Users will edit the data made available by the feature service

Volunteered geographic information (VGI) relates to collecting geospatial data and information from volunteers or the general public. Examples include the Waze app for collecting traffic data and OpenStreetMap for digitizing geospatial data.

Web GIS technologies have greatly improved our ability to collect VGI data using web pages, web maps and apps, and mobile apps.

◀...▶ Location-Based Services (LBS) ▶...▶

- ❖ Use real-time geospatial data from a mobile device or smartphone to provide information, entertainment, or security
- ❖ Since smartphones are GPS enabled, your location information can be integrated into the apps

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Location-based services relate to using your location information to locate yourself and your device and collect spatial location information. This is how a phone app knows your location: it has access to your GPS data if enabled.

Location-based services have been well integrated into mobile apps and can enhance and simplify the user experience.

ArcGIS Online

- ❖ Allows you to create maps and apps and host content for use on the Web



<https://www.arcgis.com/home/index.html>

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I will now introduce the ArcGIS Online platform, which provides web mapping capabilities and is produced by ESRI.

- ❖ Created by **ESRI**
- ❖ Integrated with **ArcGIS Pro**
- ❖ Can obtain a free account with limited access
- ❖ Can pay for an account and use more advanced functionality
 - ❖ Organization accounts
 - ❖ Allotted credits

ArcGIS Online is an ESRI product that is well integrated with ArcGIS Pro, ESRI's desktop GIS software program.

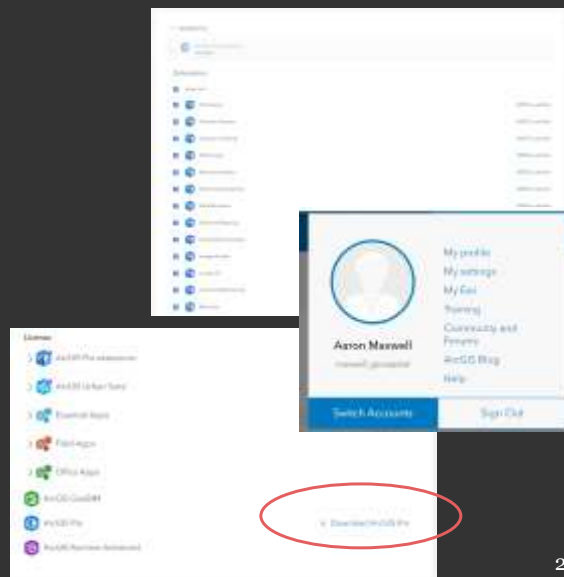
You can obtain a free ArcGIS Online account with limited capabilities. Paying for an account will provide more robust functionality.

It is also possible to set up organizational accounts to allow for collaboration, licensing, and the sharing of content. For example, at West Virginia University we have an organizational account that can be used by our faculty, staff, and students if they are provided with a user account and invited to join.

-
- Red Hat Data Studio
- Project: My Content
- My Content
- | Name | Type | Date | Owner |
|-----------------------------------|---------------------|--------------------|----------------------|
| New reports | | | |
| My Apps | | | |
| High Plains Map, WFL | Feature Layer (Hex) | 2/18/2019 11:56 AM | mcmall@geopacsis.com |
| High Plains Map, WFL | Feature Layer (Hex) | 2/18/2019 6:11 PM | mcmall@geopacsis.com |
| TGI_Memo | Feature Layer (Hex) | 2/18/2019 5:22 PM | mcmall@geopacsis.com |
| jcrs_of_interest_data | Feature Layer (Hex) | 2/18/2019 6:38 PM | mcmall@geopacsis.com |
| Main_Feature_Points | Feature Layer (Hex) | 2/18/2019 6:12 PM | mcmall@geopacsis.com |
| Indiana_Maps_2_WFL | Feature Layer (Hex) | 1/16/2018 1:52 PM | mcmall@geopacsis.com |
| Indiana_Maps_2_WFL | Feature Layer (Hex) | 1/16/2018 3:13 PM | mcmall@geopacsis.com |
| USA_Cover | Layer Package | 1/16/2018 3:58 PM | mcmall@geopacsis.com |
| usmt.pdf | Feature Layer (Hex) | 8/28/2018 12:31 PM | mcmall@geopacsis.com |
| Project_Plan_mathematics_13_Memos | Feature Layer (Hex) | 10/31/2018 6:17 PM | mcmall@geopacsis.com |
| Scholar_Derby | Feature Layer (Hex) | 5/27/2018 9:24 AM | mcmall@geopacsis.com |
- Red Hat Data Studio
- Name Default
- OK Cancel

◀▶ Licensing ArcGIS Pro with ArcGIS Online Account ▶◀

- ❖ Administrator can allow access to **ArcGIS Pro** for specific user accounts (**GIS Professional** user type)
- ❖ Can also provide access to extensions and other ESRI apps
- ❖ Can download **ArcGIS Pro** from **ArcGIS Online** once logged in
 - ❖ Click on your username
 - ❖ Select My settings
 - ❖ Navigate to Licenses



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ArcGIS Online can also be used to provide licensing for the ArcGIS Pro desktop software. If your account is tied to an organization, the administrators of the organization account can grant access to ArcGIS Pro to specific users. The GIS Professional user type will have access to ArcGIS Pro by default.

Administrators can also provide access to ArcGIS Pro extensions such as Spatial Analyst, Network Analyst, 3D Analyst, and Image Analyst.

Note that licensing agreements with ESRI generally limit the number of users that will have access to ArcGIS Pro and specific apps, so administrators may have to limit access to those that need the software or extensions.

If you have been granted access to ArcGIS Pro via your ArcGIS Online organizational account, you can download the installation file on the ArcGIS Online page once logged in by clicking on your username, selecting My settings, and navigating to License. The download file should be available to the right of the ArcGIS Pro logo.

- ❖ **Viewer** = allows member to view items that have been shared with them by other ArcGIS Online users.
- ❖ **Editor** = allows member to view and edit items that have been shared with them by other ArcGIS Online users.
- ❖ **Mobile Worker** = allows member to view and edit items that have been shared with them by other ArcGIS Online users with a primary focus on field apps.
- ❖ **Creator** = allows member to view, edit, create, and share content.
- ❖ **GIS Professional** = allows member to view, edit, create, and share content. Member also has access to the ArcGIS Pro desktop application.

Your rights and capabilities on ArcGIS Online are governed by your User Type. For example, a Creator is able to view, edit, create, and share content within the organization and to the general public. Your User Type will be defined by your organization administrators. Read through the examples on this slide to understand the differences between user types. Note that ESRI often updates the available user types or their associated names.

- ❖ **Viewer** = allows member to view items that have been shared with them by other ArcGIS Online users. The member will also be able to join groups within the organization.
- ❖ **Data Editor** = allows the member to view and edit data. The member will also be able to join groups within the organization.
- ❖ **User** = allows member to view items that have been shared with them by other ArcGIS Online users. Users can also create maps and apps, edit features, add items, share content, and create groups.
- ❖ **Publisher** = allows member to have all the privileges of users plus the ability to publish features and map tiles as hosted web layers.
- ❖ **Facilitator** = publisher privileges plus the ability to invite partnered collaboration members to groups. This includes the privilege to create and manage partnered collaboration groups, invite members from another organization into groups, and create shared update groups.
- ❖ **Administrator** = allows member the same privileges as publishers plus the ability to manage the organizational account and other users.

You can also be assigned a role within your organization. Different roles are described on this slide.

- ❖ Your instructor will assign a user account (or, you may have access via your WVU username and password)
- ❖ You will have a user type of **GIS Professional** and a role of **Publisher**
- ❖ You will be able to create and share content
- ❖ Your accounts and content will be deleted once the course is completed
- ❖ You can use your own account if you prefer, but you must be able to create content and share

In my courses, I provide access to ArcGIS Online and ArcGIS Pro by setting up ArcGIS Online organizational accounts for my students. We are migrating to allowing all students access via their WVU username and password.

I generally assign students to the GIS Professional user type and the Publisher role so that they can create, publish, and share content on ArcGIS Online.

They will also have access to ArcGIS Pro and all extensions that we license. Once a student graduates or completes a course where the software is required, their account and associated content will be deleted.

We provide more permanent accounts to faculty and staff, including some graduate students.

⏮️ Administrative Tasks ⏭️



- ❖ Invite new members
- ❖ Change user type and roles
- ❖ Add/delete members/content
- ❖ Reset passwords
- ❖ Manage add-on licenses
- ❖ Manage and allocate credits
- ❖ Change/manage organizational settings

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Administrators for an organizational account have additional responsibilities and privileges within an organization.

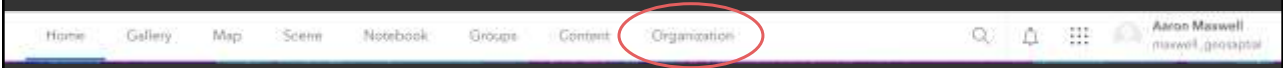
For example, they are able to invite new members to the organization, change User Types and Roles for members, add and delete members and their content, reset user passwords, manage add-on licenses, manage the allocation of credits, and change and manage settings for the entire organizational account.

I am an administrator for the WVU organizational account. So, I am able to invite new members, add and delete members, reset passwords, and provide access to add-on licenses. For example, I can provide students access to ArcGIS Pro using student ArcGIS Online accounts.

Administrative Tasks



- ❖ Administrators will have **Organization tab**
- ❖ Within this tab, administrator can see:
 - ❖ overview of Organization account
 - ❖ overview of credit usage
 - ❖ overview of licenses
 - ❖ all member accounts



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This slide lists some common tasks that can be performed by administrators within an organization.

Organization Information



- ❖ Subscription Number
- ❖ License renewal date
- ❖ Number of members
- ❖ License and credit usage
- ❖ Add-on license usage

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The Organization tab provides information about the organization's ESRI account, including the information listed on this page. This information is generally only made available to administrators.

Adding Members

❖ **Organization Tab** → **Members** → Invite Members

❖ Manually enter info for single new user

❖ Use **formatted CSV** file for multiple users

invite members

First Name	Last Name	Email	Username	Role	User Type
Example	User	newUser@gmail.com	newUser_AdiQL	Publisher	GIS Professional Advanced

Method

☐ Add members without sending invitations

You will be setting up the username and password for each member. You must enter the username and password. The temporary password must meet the minimum strength requirements. The member will be prompted to change their password when they first sign in. An invitation email is not sent if you don't have an email address for a particular member (see an invitation email address).

☒ Add members and notify them via email

You will be setting up the username and password for each member. You don't need to set up a password for each member. You will send an email to each member to set up their account. You will also send an email to each member to set up their account.

☐ Invite members to join using an account of their choice

You will be providing an email address for each member. Members will have to respond to an email invitation sent to them by ArcGIS Online. They can join the organization by creating a new account or by connecting their existing ArcGIS Public account. The new account can use SAML, Okta ID Connect, ArcGIS or social logins as configured by your organization.

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Administrators can invite new members to join by adding them one-at-a-time. Alternatively, they can add multiple new users at once by uploading a CSV file. This CSV file will require First Name, Last Name, Email, Username, Role, and User Type fields. In the example on this slide, the new user is being assigned a Publisher role and a GIS Professional Advanced user type.

If the administrator selects “Add members without sending invitation”, each member will need to be provided with a password. Also, the user will not get sent an email to notify them that they have been added. In contrast and if “Add members and notify them via email” is selected, then a password does not need to be provided and the new user will be sent an email to claim their account, set a password, and set up security questions.

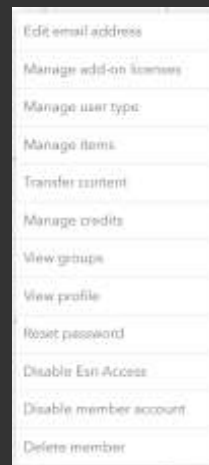
Note that all usernames within an organization must be unique.

Member Actions



- ❖ Edit email address
- ❖ Manage add-on licenses
- ❖ Manage user type
- ❖ Manage items
- ❖ Transfer content
- ❖ Manage credits
- ❖ View groups
- ❖ View profile
- ❖ Reset password
- ❖ Disable/enable ESRI access
- ❖ Disable member account
- ❖ Delete member

- *Deleting a member cannot be undone
- *Must delete content before deleting a member
- *Can transfer content to another user before deleting a member



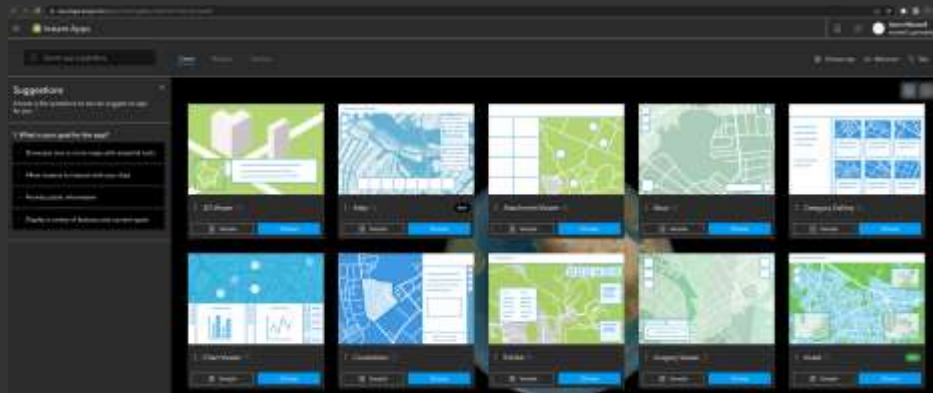
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This slide lists some administrative task that can be performed by administrators for specific user accounts. It is important to note that deleting a member cannot be undone. Also, you must delete the user's content prior to deleting their account. If you do not want to delete the user's content, items can be transferred to another user.

Presenting Your Data



❖ **Instant Apps** = pre-made applications that you can load your layers into



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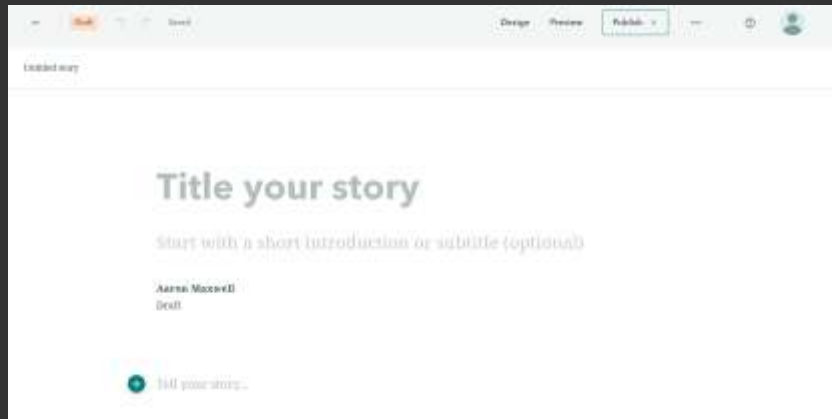
ArcGIS Online provides many options for generating web apps. For example, Instant Apps allow you to configure a template.

These are generally easy to set up and deploy; however, customization is limited. We will explore using Instant Apps in later modules.

Presenting Your Data



❖ **ArcGIS Storymaps** = configurable apps designed for developing narratives using maps, text, and media



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ArcGIS Storymaps are a type of Instant App that allow you to build webpages with a variety of content including text, maps, media, and links. These are generally easy to use, edit, and configure. You can even use them to build webpages without any maps. We will explore Storymaps in a later module.

Presenting Your Data



❖ **ArcGIS Experience Builder** = web-based tool for generating multi-page websites that do not need to be centered around a map



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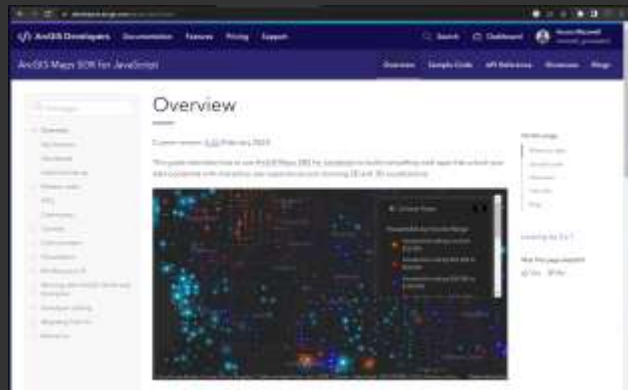
ArcGIS Experience Builder offers more customization than the Configurable Apps. It is a tool to generate multipage websites with a variety of content. You don't even need to include geospatial data or maps; you could design an entire webpage without any maps or geospatial data or design pages with lots of maps. All this can be done without any coding. We will explore the Experience Builder in detail in a later module.

❖ Dashboards =
focused on data
visualization and data
insights



Dashboards are used as a means to monitor data. These apps are more focused on data as opposed to maps. You will learn to make dashboards in this course.

❖ **ArcGIS Maps SDK for JavaScript** = offers fully customizable web maps and apps (requires coding)



<https://developers.arcgis.com/javascript/>

The ArcGIS Maps Software Development Kit (SDK) for JavaScript allows for the generation of interactive web maps using JavaScript. It allows for a high level of customization; however, the user must have an understanding of the JavaScript coding language.

At the time of this writing, the ArcGIS Maps SDK for JavaScript is in version 5.0.

ArcGIS Enterprise

⏮️ Different from ArcGIS Online ⏭️

- ❖ Not hosted by ESRI
- ❖ Hosted by user on a physical or virtual server

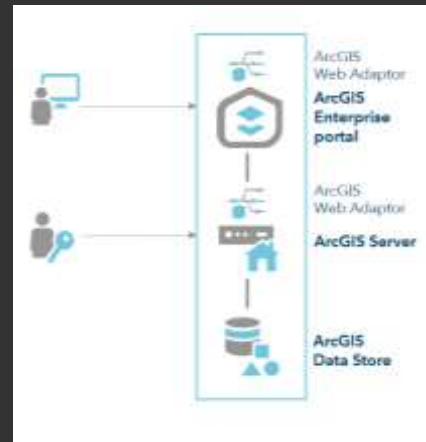
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We will not use ArcGIS Enterprise in this course. However, I provide a brief introduction to its components here.

A key difference from ArcGIS Online is that the user hosts an ArcGIS Enterprise instance on their own physical or virtual server as opposed to using ESRI's hardware.

Components

- ❖ **Portal for ArcGIS** = front-end web GIS interface (like AGOL but runs on users' infrastructure)
- ❖ **ArcGIS Server** = GIS engine that processes and publishes services
- ❖ **ArcGIS Data Store** = managed databases
- ❖ **ArcGIS Web Adaptor** = Connects ArcGIS Enterprise to user web server



<https://enterprise.arcgis.com/en/get-started/11.4/windows/what-is-arcgis-enterprise-.htm>

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There are several components to ArcGIS Enterprise, which I introduce on the following slides.

- ❖ Provides the web interface for users
- ❖ Manages users, groups, and permissions
- ❖ Stores web maps, apps, and content items
- ❖ Enables sharing and collaboration
- ❖ Provides organization settings

This slides outline the use of Portal for ArcGIS within an ArcGIS Enterprise instance. It functions similarly to ArcGIS Online and allows for managing ArcGIS Enterprise and associated user accounts, data, maps, apps, and other items or assets.

- ❖ Hosts map services
- ❖ Hosts feature services
- ❖ Runs geoprocessing services
- ❖ Runs image services
- ❖ Runs network analysis and routing

Different types of ArcGIS servers are available to provide different types of services.

Web Adapter



- ❖ Provides friendly URLs
- ❖ Routes traffic to Portal and Server
- ❖ Integrates with enterprise security
- ❖ Enables reverse proxy
- ❖ Runs inside of:
 - Internet Information Services
 - Apache HTTP Server

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Web Adapter is used to allow different components of ArcGIS Enterprise to talk to each other using the web and associated protocols.

- ❖ Enterprise geodatabase
 - PostgreSQL
 - Microsoft SQL Server
 - Oracle Database

Data are stored inside of an enterprise database. Examples include PostgreSQL, Microsoft SQL Server, and Oracle Database.

Types of ArcGIS Servers

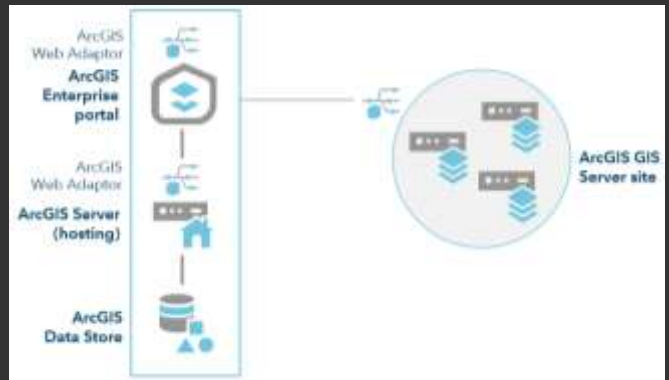
- ❖ ArcGIS GIS Server
- ❖ ArcGIS Image Server
- ❖ ArcGIS GeoEvent Server
- ❖ ArcGIS Notebook Server
- ❖ ArcGIS Workflow Manager Server
- ❖ ArcGIS Knowledge Server
- ❖ ArcGIS Video Server

<https://enterprise.arcgis.com/en/get-started/11.4/windows/additional-server-deployment.htm>

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This slide again lists the different types of servers available within ArcGIS Enterprise. These different types of servers are discussed on the following slides.

- ❖ Hosting server
- ❖ General purpose GIS service
- ❖ References data sources and geodatabases



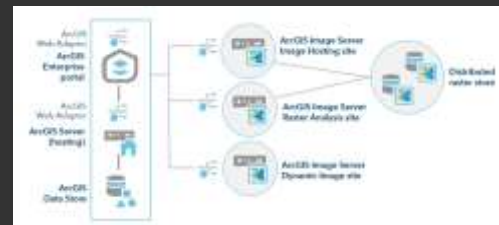
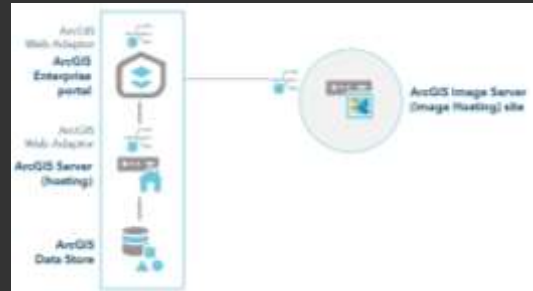
<https://enterprise.arcgis.com/en/get-started/11.4/windows/additional-server-deployment.htm>

An ArcGIS GIS Server is a general-purpose server that references data sources and geodatabases for consumption by clients making requests.

◀◻▶ ArcGIS Image Server



- ❖ Dynamic image services from mosaic datasets
- ❖ Raster analysis using distributed processing

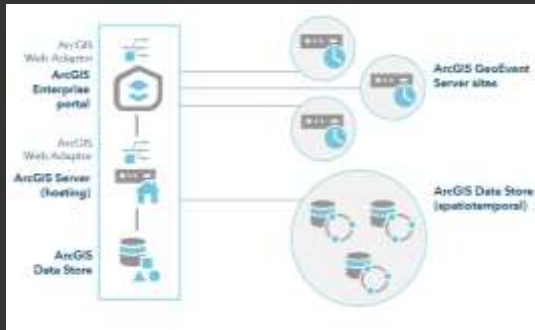


<https://enterprise.arcgis.com/en/get-started/11.4/windows/additional-server-deployment.htm>

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ArcGIS Image Server provides access to image or raster data and raster analysis processing services.

- ❖ Enables real-time, event-based data streams from sensor networks—whether stationary, mobile, or an Internet of Things (IoT)—to be integrated as data sources in your enterprise GIS.



<https://enterprise.arcgis.com/en/get-started/11.4/windows/additional-server-deployment.htm>

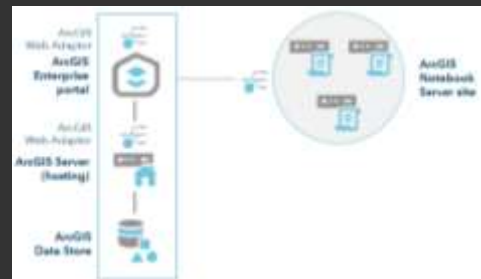
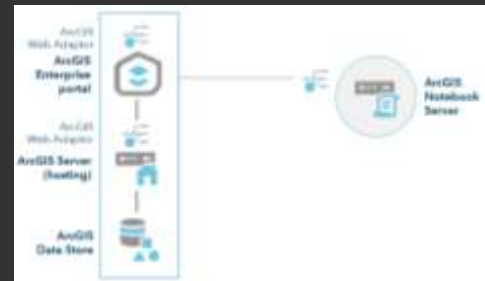
ArcGIS GeoEvent Servers are used for processing and storing data generated by the Internet of Things (IoT) and sensor networks.

◀◻▶ ArcGIS Notebook Server



- ❖ Data science platform integrated with the ArcGIS Enterprise portal
- ❖ Enables ArcGIS Enterprise deployment to host and run ArcGIS Notebooks.
- ❖ Python programming language
- ❖ Perform spatial analysis, craft data science and machine learning workflows, manage GIS data and content, and automate ArcGIS Enterprise administrative tasks

<https://enterprise.arcgis.com/en/get-started/11.4/windows/additional-server-deployment.htm>

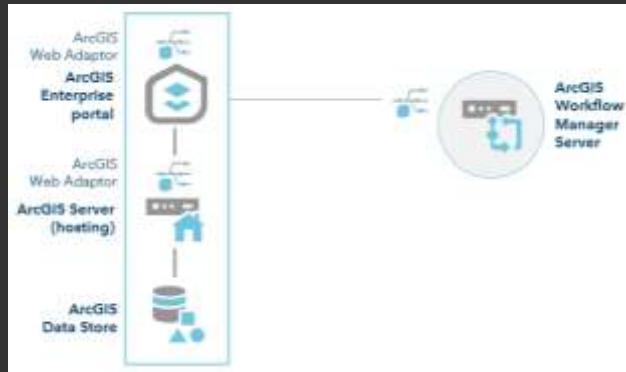


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ArcGIS Notebook Server allows for executing Python notebooks for a variety of tasks.

◀◻▶ ArcGIS Workflow Manager Server ▶◻▶

- ❖ Workflow management system that automates and simplifies many aspects of performing and managing GIS and non-GIS work in your organization



<https://enterprise.arcgis.com/en/get-started/11.4/windows/additional-server-deployment.htm>

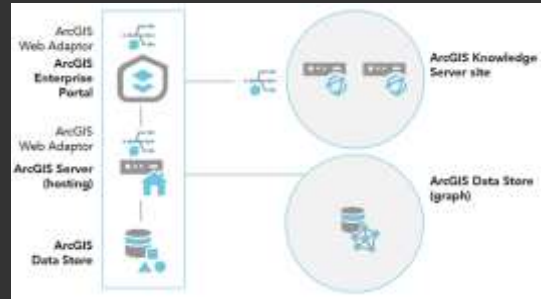
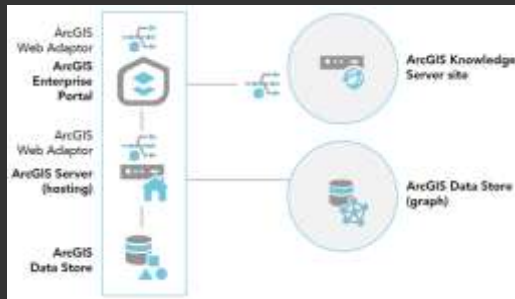
55

ArcGIS Workflow Manager Server is used to manage workflows within an organization.

◀◻▶ ArcGIS Knowledge Server



- ❖ Enables ArcGIS Enterprise to model relationships between entities using knowledge graph layers



ArcGIS Knowledge Server is used to implement knowledge graphs.

- ❖ **Federated** = ArcGIS Server has been linked to and integrated with Portal for ArcGIS
- ❖ Server is managed by Portal for ArcGIS

An ArcGIS Enterprise is said to be federated when all components are linked to and integrated with Portal for ArcGIS. This allows Portal to manage all other components of the ArcGIS Enterprise instance. This is important for the system to function correctly and holistically.

Open-Source Alternatives

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There are open-source alternatives to ArcGIS Online and ArcGIS Enterprise, which we briefly introduce in this section.



<https://www.osgeo.org/>

- ❖ OSGeo
- ❖ Advocates for open software, data, education, science, and standards

The Open Source Geospatial Foundation supports and promotes collaborative development of open geospatial technologies and data.

OSGeo is involved in many projects including QGIS, GRASS, GDAL, and PostGIS.

- ❖ GUI
- ❖ Integration with **Python**
- ❖ Integration with **GDAL**, **GRASS**, **SAGA**, and **PostgreSQL/PostGIS**
- ❖ Part of **OSGeo Project**
- ❖ Version 1.0 released in 2009
- ❖ Available for multiple operating systems



<https://qgis.org/en/site/>

QGIS is one of the most common and heavily used open-source desktop GIS software packages. It also does not have a steep learning curve, since most tasks can be completed without coding or scripting.

QGIS has a graphical user interface (GUI) that is very intuitive. It is also available for use on multiple operating systems including Windows, Mac, and Linux.

Further, QGIS allows for the use of other open-source tools within its interface, including GRASS, SAGA, and GDAL.



❖ Field mapping using QGIS projects



QField extends QGIS for field mapping and mobile GIS tasks.



- ❖ Geospatial Data Abstraction Library
- ❖ Read and write vector and raster data
- ❖ Convert between raster and vector data formats
- ❖ Translate and process data
- ❖ Most open-source geospatial software rely on GDAL
- ❖ Initially released in 2000



<https://gdal.org/>

Many open-source and commercial geospatial software packages make use of the Geospatial Data Abstraction Library (GDAL). GDAL provides data standards for vector and raster spatial data.

The defined vector and raster data abstraction models allow for the use of data in a variety of formats and the conversion between data formats.

- ❖ Formerly **PROJ.4**
- ❖ Open-source software/library for performing conversions between cartographic projections/coordinate systems
- ❖ Standard syntax for defining projections and coordinate systems
- ❖ Most open-source geospatial software rely on PROJ



<https://proj.org/>

Example PROJ Strings:

NAD83 UTM Zone 17N

```
+proj=utm +zone=17 +ellps=GRS80 +datum=NAD83 +units=m
+no_defs
```

US Contiguous Albers Equal Area Conic

```
+proj=aea +lat_1=29.5 +lat_2=45.5 +lat_0=37.5 +lon_0=-96
+x_0=0 +y_0=0 +ellps=GRS80 +datum=NAD83 +units=m
+no_defs
```

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PROJ (formerly PROJ.4) is also used in many open-source and commercial software libraries.

It supports standards for defining geographic and projected coordinate systems and converting between specific systems.

PROJ strings offer a common text syntax for describing coordinate systems and their components, such as projection systems, datums, ellipsoids, origins, false eastings and northings, standard parallels and/or meridians, and units of measurement.

Example PROJ strings for the NAD83 UTM Zone 17 North and US Contiguous Albers Equal Area Conic projections are provide on the slide.

- ❖ Open-Source Relational Database
- ❖ **PostGIS** extends PostgreSQL for handling spatial data
- ❖ Integrated with **QGIS**
- ❖ Initially released 2001



<https://www.postgresql.org/>



<https://postgis.net/>

QGIS is well integrated with the free and open-source PostgreSQL relational database software. PostgreSQL is extended to handle geospatial data and processing using PostGIS.

One of the original uses of QGIS was to interface with PostgreSQL. For example, new data can be digitized in QGIS and saved directly to a PostgreSQL database.

- ❖ **JavaScript** library for interactive web maps
- ❖ **Client-Side**



<https://leafletjs.com/>



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In this course, we will explore the Leaflet JavaScript library as a free and open-source alternative to ESRI products and the ArcGIS Maps SDK for JavaScript specifically.

❖ GeoNode (~Portal)



- User authentication
- Data catalog
- Map sharing
- Metadata management
- Group permissions

❖ GeoServer (~ArcGIS Server)

- Serve WMS, WFS, WCS, and WMTS



❖ Spatial Database (~Data Store)

- PostgreSQL/PostGIS



❖ Nginx/Apache HTTP Server (~Web Adapter)



❖ Leaflet (~ArcGIS web apps)



❖ OpenLayers (~ArcGIS web apps)



❖ MapLibre GL JS (~ArcGIS web apps)



There are a variety of free and open-source tools used to implement web GIS. This slide provides descriptions of some key components.

Accessibility

⌂ How to Make Webpages for Accessible ⌂

- ❖ Alt text for images/graphics
- ❖ Use proper HTML tags
- ❖ Sufficient color contrast
- ❖ Avoid fixed font sizes
- ❖ Avoid color-only communication
- ❖ Provide captions for videos
- ❖ Include audio transcripts
- ❖ Avoid audio-only interactions
- ❖ Consistent navigation and layout
- ❖ Provide helpful error messages
- ❖ Use accessible fonts
- ❖ Support keyboard-only navigation

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As you design web maps, apps, pages, and sites, it is important to consider accessibility. This slide lists key factors and considerations for making your products accessible.

Web Content Accessibility Guidelines (WCAG)

- ❖ **Perceivable**: Users can perceive content
- ❖ **Operable**: Users can interact with it
- ❖ **Understandable**: Content is clear
- ❖ **Robust**: Works across devices and assistive tech



<https://www.w3.org/TR/WCAG21/>

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I recommend consulting the Web Content Accessibility Guidelines (WCAG) as you generate content.



This is the end of this lecture module.

Please return to the West Virginia View
Webpage for additional content.



Thanks! Hope you found this useful.