Indexed 3D Scene Layer (I3S) – An Open 3D Standard

Chris Andrews | 3D Product Manager

Tamrat Belayneh | Lead Software Developer – 3D Services

Sean William Morrish| Product Engineer

Speaker

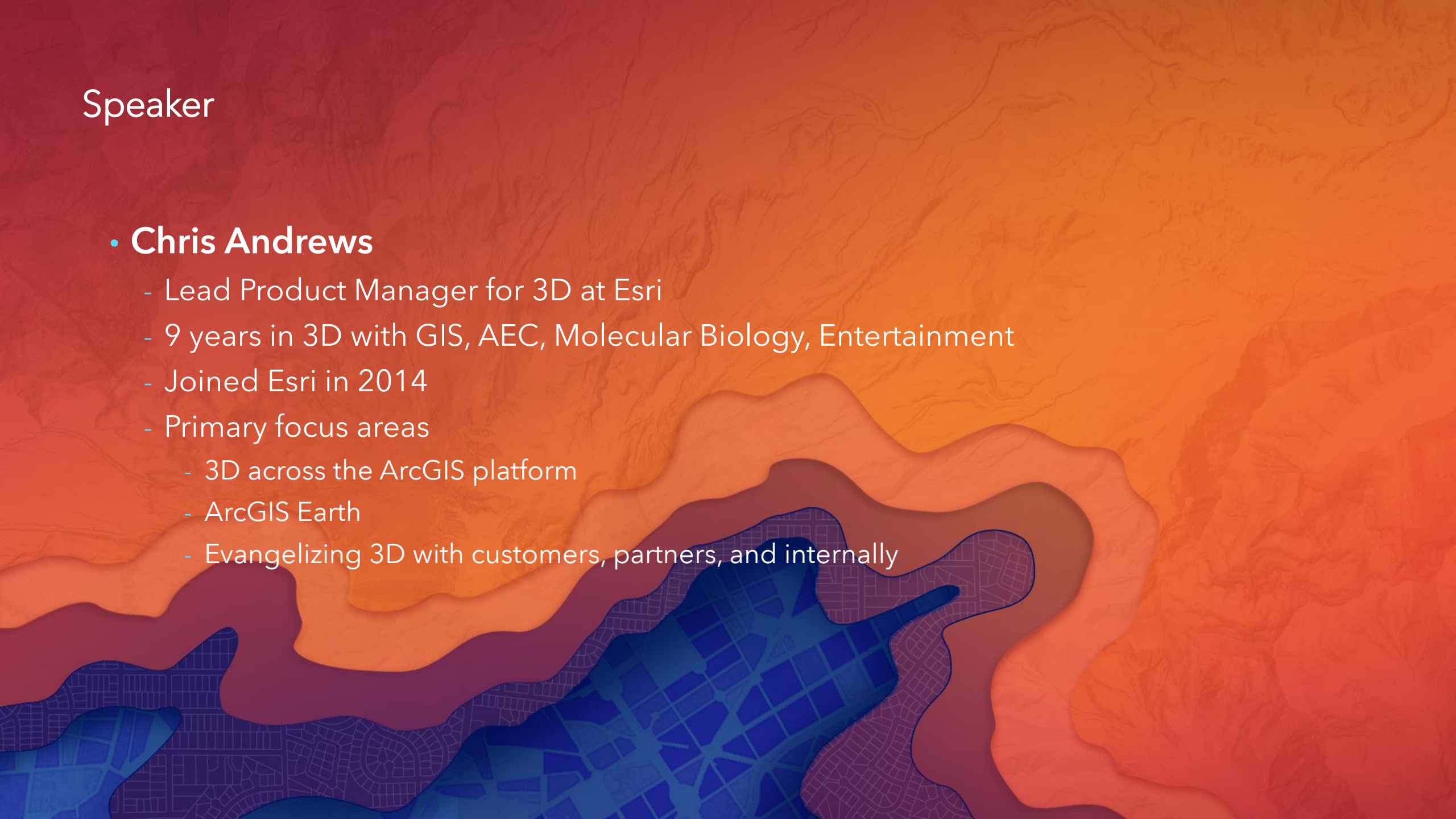
- **Tamrat Belayneh**
  - Lead Software Developer for 3D services at Esri
  - Over 18 years in 3D software Development
  - Joined Esri in 2000
  - Primary focus areas
    - 3D Services
    - Indexed 3D Scene Layer Specification (I3S)
    - 3D across the ArcGIS platform

Speaker

- **Sean Morrish**
  - 3D Product Engineer
  - 15 years AEC experience
  - 4 years with Esri as product engineer in 3D
  - Primary Focus areas
    - 3D Scene Layer Services
    - Data prep and processing (3D Objects, Points, Mesh, Point Cloud)
    - Testing and implementation of i3S Scene Layers across the platform

Speaker

- **Chris Andrews**
  - Lead Product Manager for 3D at Esri
  - 9 years in 3D with GIS, AEC, Molecular Biology, Entertainment
  - Joined Esri in 2014
  - Primary focus areas
    - 3D across the ArcGIS platform
    - ArcGIS Earth
    - Evangelizing 3D with customers, partners, and internally

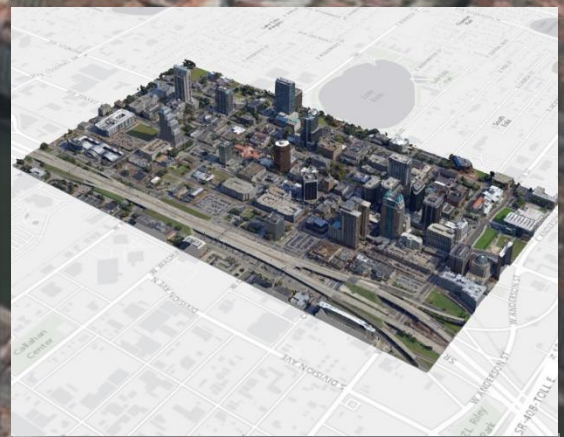


3D content is large, heterogeneous, and distributed

Generated 3D features

Photogrammetrc 3D Features

3D Point Cloud



Reality Capture 3D Mesh

Core 3D Capability | Anywhere In Any Environment

- Transform 2D and 3D GIS into a single GIS workflow
- Reuse dynamic services across clients
- Securely collect, manage, curate 3D data
- Conduct analysis across real-time and historical data
- Create tailored experiences for different types of users

Cross-platform

Open

Accessible

Standards

Enabling customers & partners through sharing and integration

Open Software, Standards and Data enable organizational resiliency

- Ensure access to data
- Guarantee interoperability
- Enable innovation
- Encourage usage and adoption

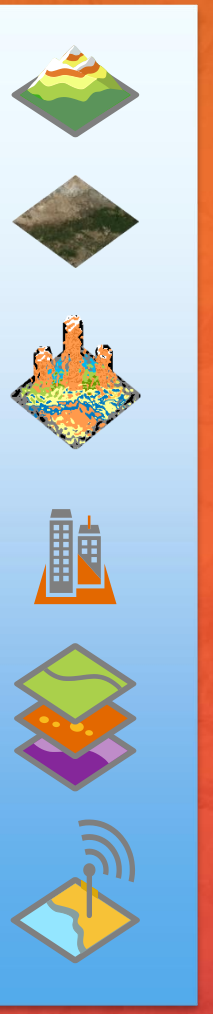
I3S	Scalable 3D scene content for visualization and distribution
LERC	Raster (imagery and elevation) compression technology for 2D and 3D
GeoREST	Esri open REST APIs for access to any kind of GIS content and services

I3S

- Indexed 3D Scene (I3S) layer specification
  - Open specification for 3D layers
  - Shared under Creative Commons licensing
  - OGC community currently considering I3S as a Community Standard

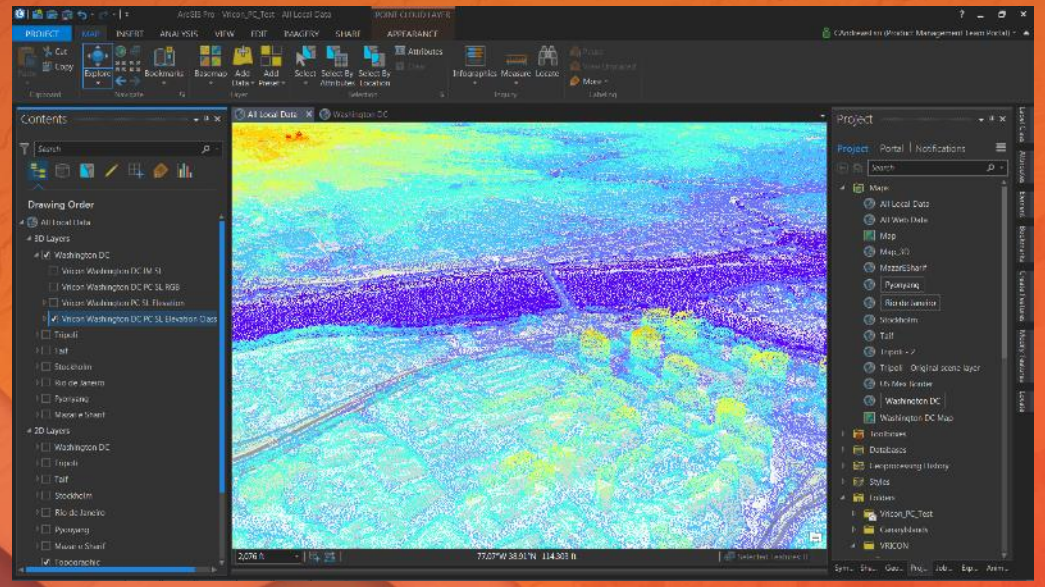
  - Describes a scalable scene cache with attributes and indexing
  - Multiple levels of detail
  - Can be streamed over the internet
  - Can be used locally on disk as a package

  - Opportunity for future layer types to accommodate new data types
  - Open for feedback and modification



Web Scenes, Scene Layers

- **Web Scene**
  - Vehicle for cross-platform 3D capability
  - Collection of layers, environment settings, slides, *animation*
  - Essential for 3D apps on any platform or experience

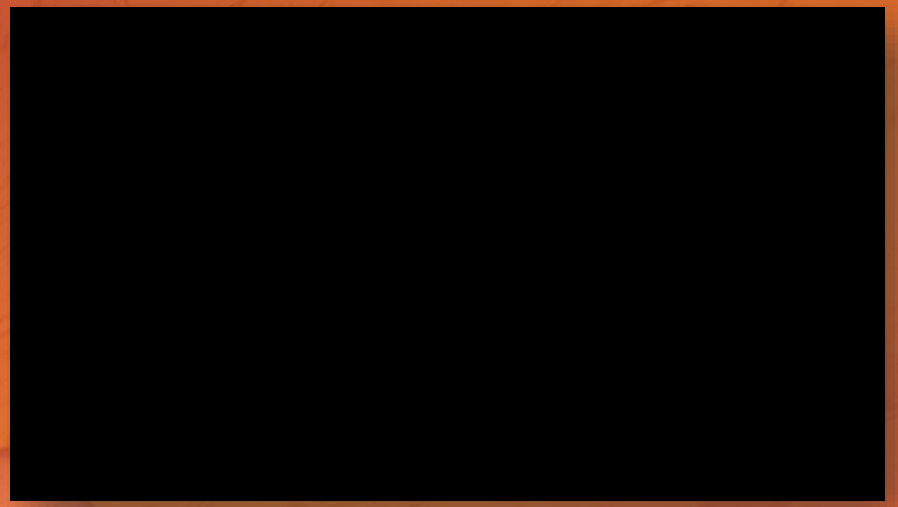


- **Scene Layer**
  - Scalable cache of graphics, styles, and attributes
  - 3D Objects, 3D Points, Integrated Meshes, Point clouds
  - Future: Enhanced support for: BIM (2017), 3D Lines, 3D Polygons

- **Reuse, Share, Extend**

3rd party adoption of I3S

- Integrated mesh
  - VRICON, Pix4D, and Bentley sharing packages or services in I3S format
  - Supports Drone2Map
- Additional partners coming soon
- Expanding list of layer types and layer capability



I3S has no commercial dependencies

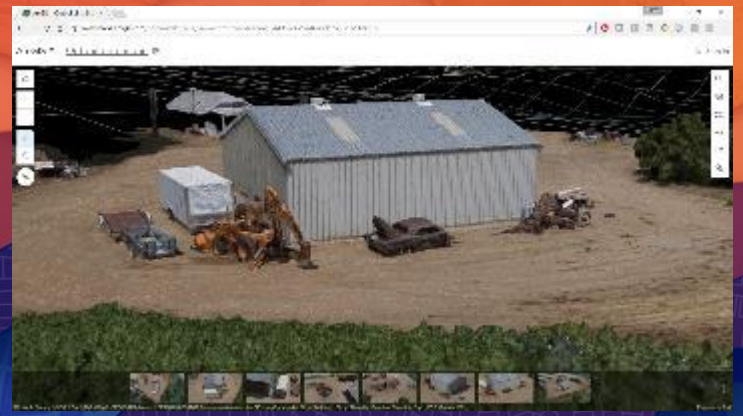
- **Any organization can:**
  - Access and read the openly published spec
  - Inspect I3S layers with common tools such as JSON browsers, zip file readers, and text editors
  - Create an I3S layer according to the specification
  - Read an I3S layer created by themselves or another application

- **I3S will be improved by having many interested organizations creating and consuming content**

I3S in practice

Users can

- Create I3S content in Esri and non-Esri apps
- Acquire I3S content from vendors
- Share and distribute I3S content freely



Partners can

- Build their own apps to write I3S content
- Build their own apps to read, analyze, and display I3S content
- Sell apps that can read/write I3S
- Contribute requirements and changes into the I3S community

Indexed 3D Scene Layers are supported across the ArcGIS platform

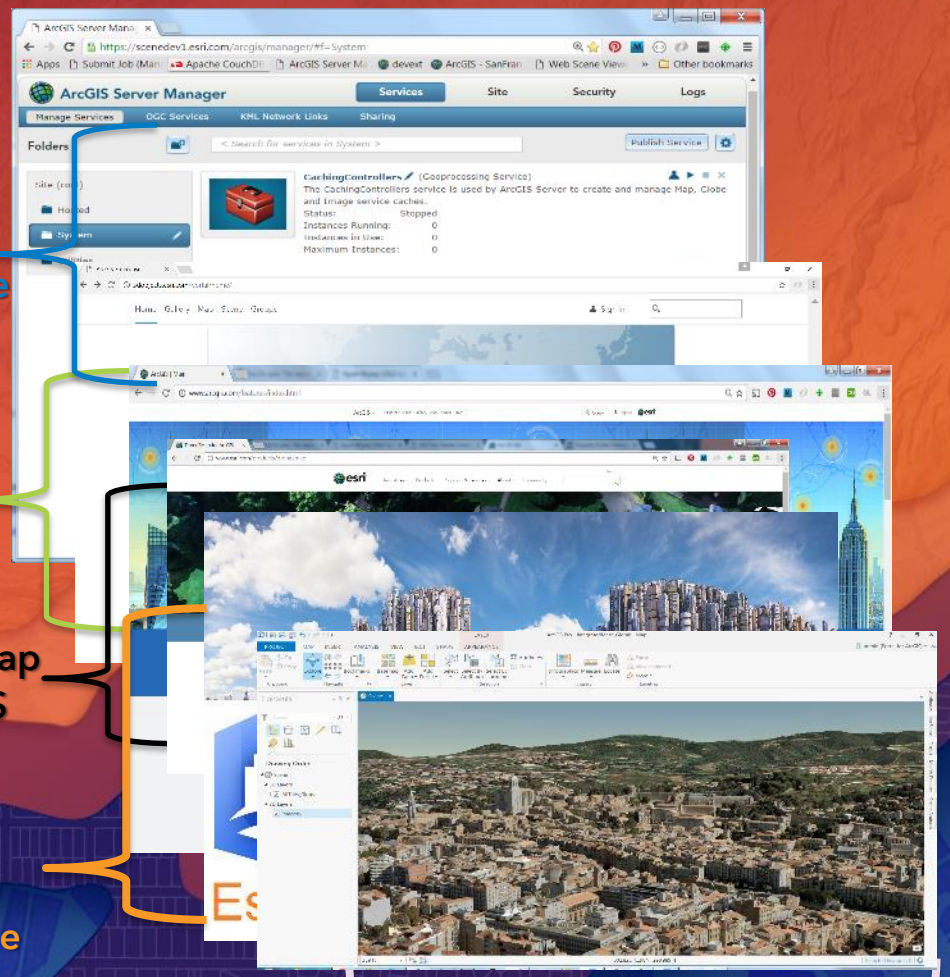
Publishing/Sharing

ArcGIS Enterprise

ArcGIS Online

Drone2Map for ArcGIS

Esri CityEngine



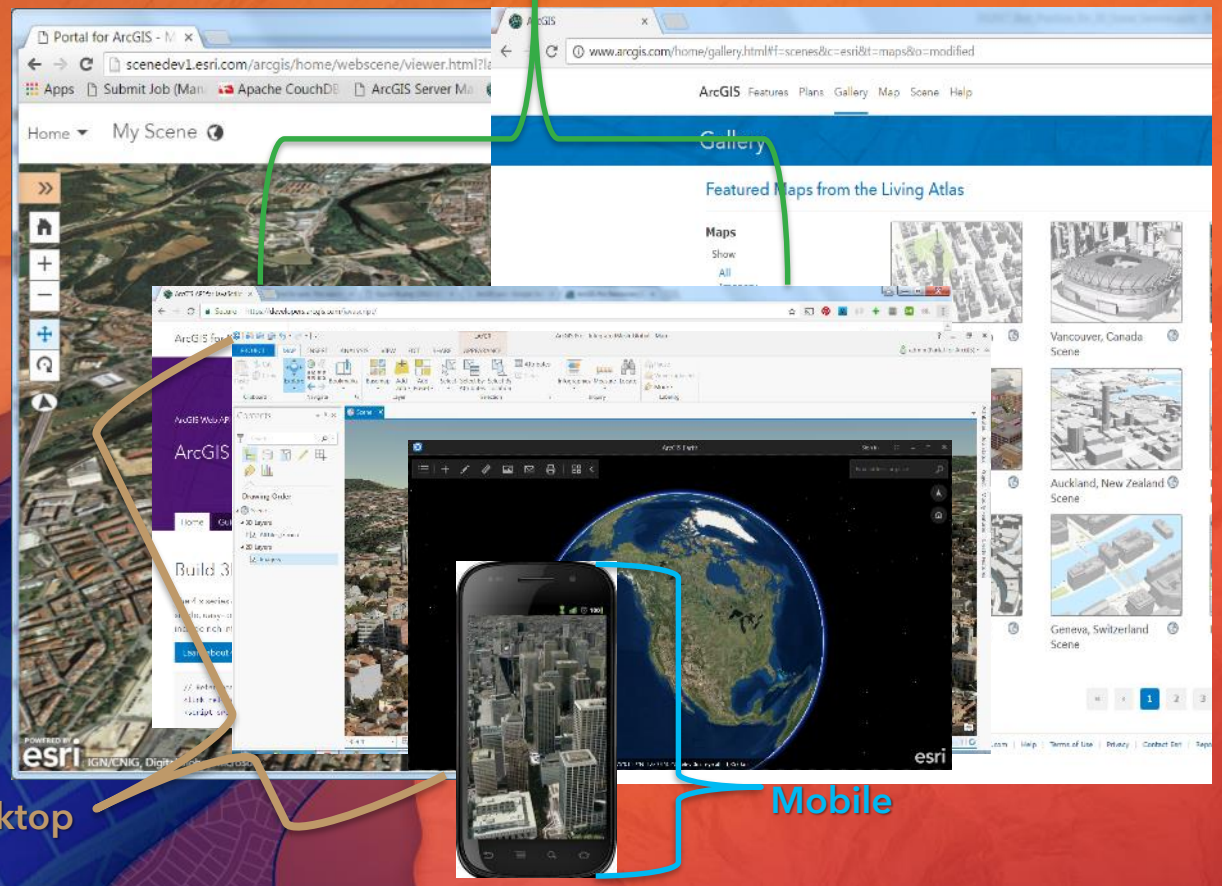
ArcGIS Pro

Consuming

Web

Desktop

Mobile



Indexed 3D Scene Layers (I3S) – What is it ?

- Open standard for storage and transmission of large, heterogeneous 3D geospatial data sets
- Cloud, Web and Mobile friendly based on JSON, REST and modern web standards
- Support 3D geospatial content, various coordinate systems along with a rich set of layer types
- An I3S data set, referred to as a *Scene Layer* is:
  - a container for *arbitrarily large* amounts of *heterogeneously* distributed 3D geographic data

Indexed 3D Scene Layers (I3S) – What is it ?

- I3S is in process to become an OGC community standard
- The standard includes specification for Scene Layer Package (SLPK) – An archive that captures all node resources of a scene layer and allows direct access
- I3S can serve as a common tool to package and disseminate, a variety of GIS content
- Both I3S and SLPK are licensed under Creative Commons
- Available @ https://github.com/Esri/i3s-spec

Indexed 3D Scene Layers (I3S) – What is it ?

I3S Design Principals for a 3D GIS visualization format

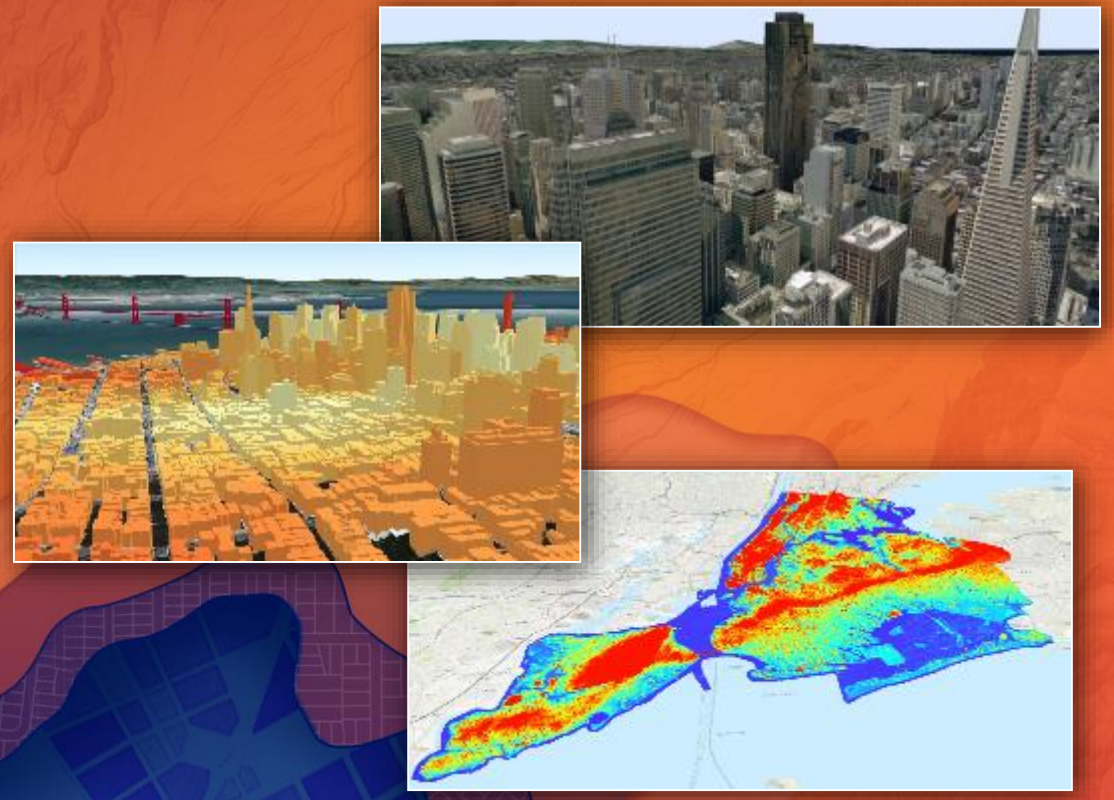
1. **Web friendly:** JSON + Typed Arrays
2. **Mobile friendly:** Works good with varying bandwidth
3. **Extensible:** Support different types of content
4. **Declarative:** Reduce required implicit knowledge
5. **Efficient:** Use spatial indexing for quick delivery
6. **Scalable:** Provide Level of Detail Support
7. **Protected:** Ensure that content is protected
8. **Open:** Full Specification publicly accessible

https://github.com/Esri/i3s-spec

Scene Layer types and *profiles*

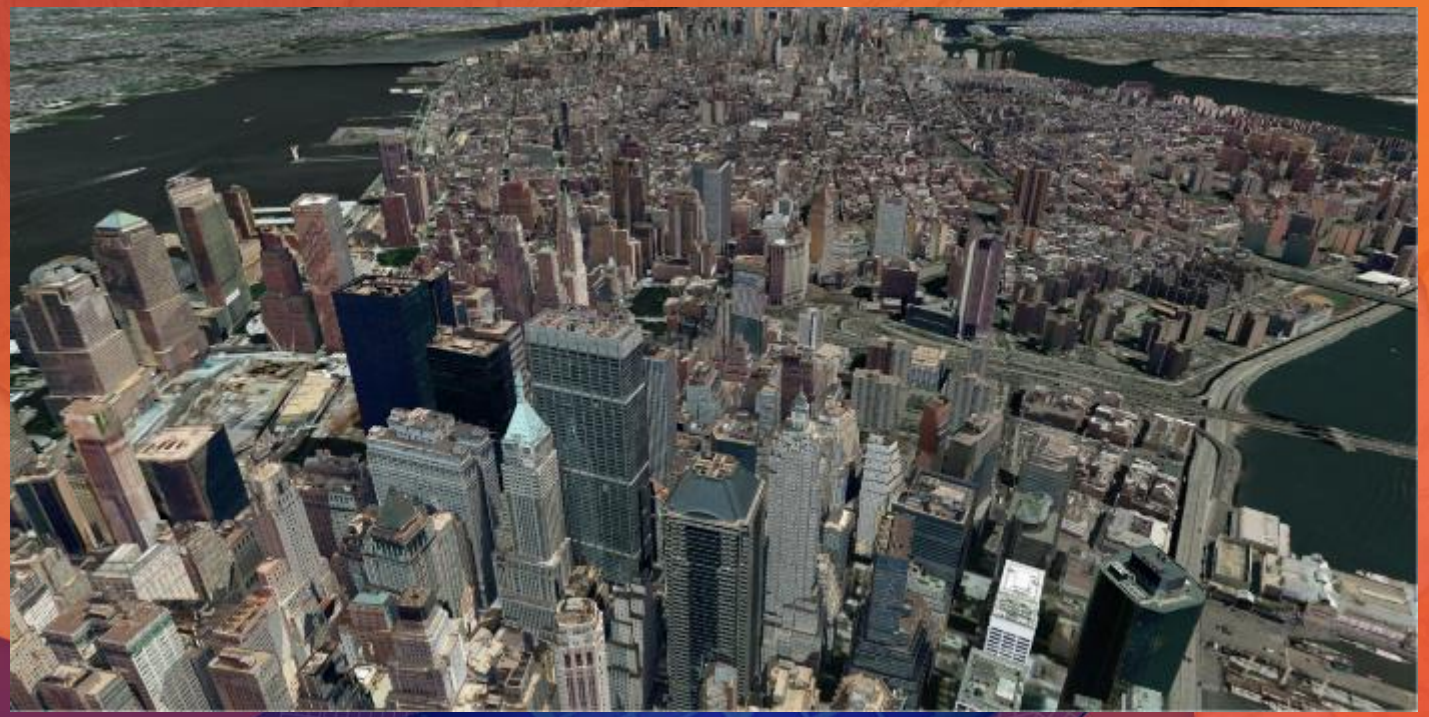
Support different geometry types

- 3D Objects
- Integrated Meshes
- Points
- Point Clouds



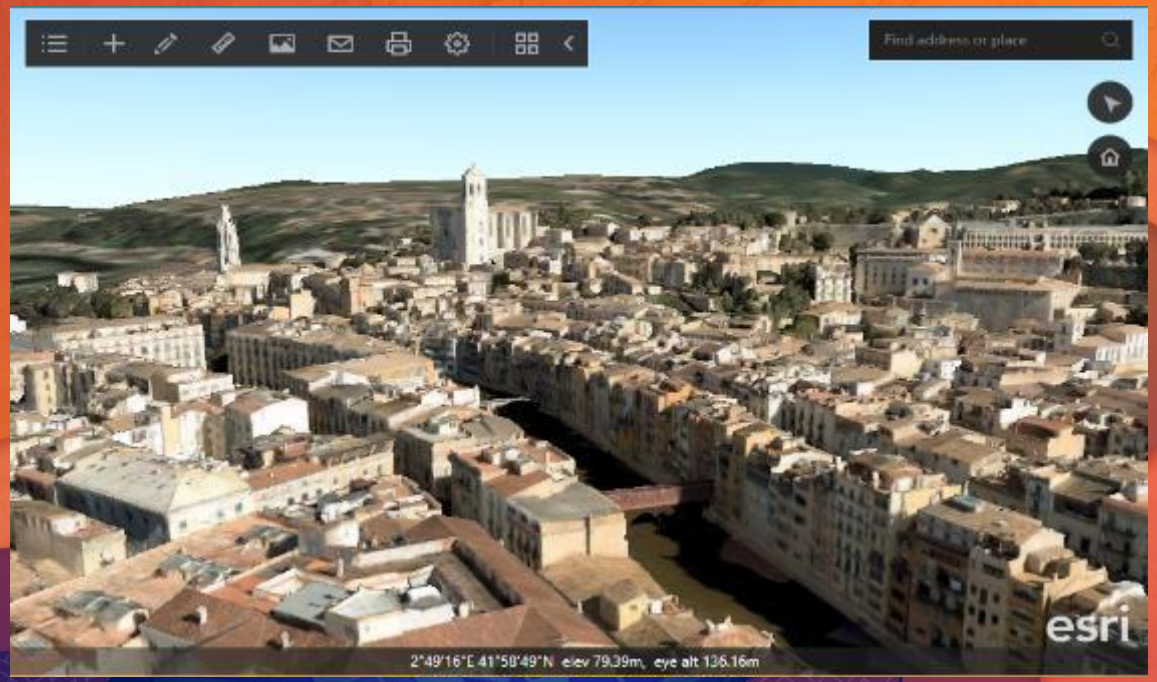
Indexed 3D Scene Layers (I3S)

- **3D Objects**
  - **Example: Building Exteriors**
  - **Sources: Derived from GIS Data, as well as 3D models in various formats**



Indexed 3D Scene Layers (I3S)

- **Integrated Meshes**
  - **Examples: Mesh surface representing the skin of the Earth, including vegetation, buildings and roads**
  - **Sources: Derived from satellite, aerial or drone imagery via dense matching photogrammetry, or calculated**



Indexed 3D Scene Layers (I3S)

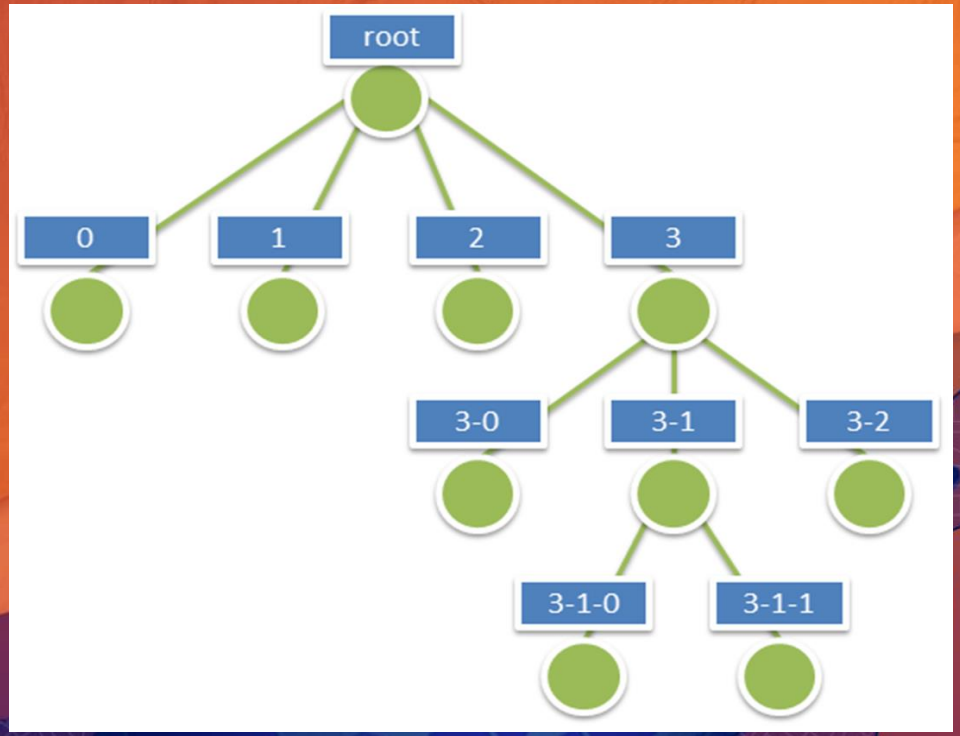
- **Points**
  - **Examples: Hospitals, schools, trees, cars**
  - **Sources: Feature locations combined with Instanced 3D models generated by hand**

Indexed 3D Scene Layers (I3S)

- **Point Clouds**
  - **Example: LiDAR data sets**
  - **Sources: Typically sensor-collected or Photogrammetrically derived**

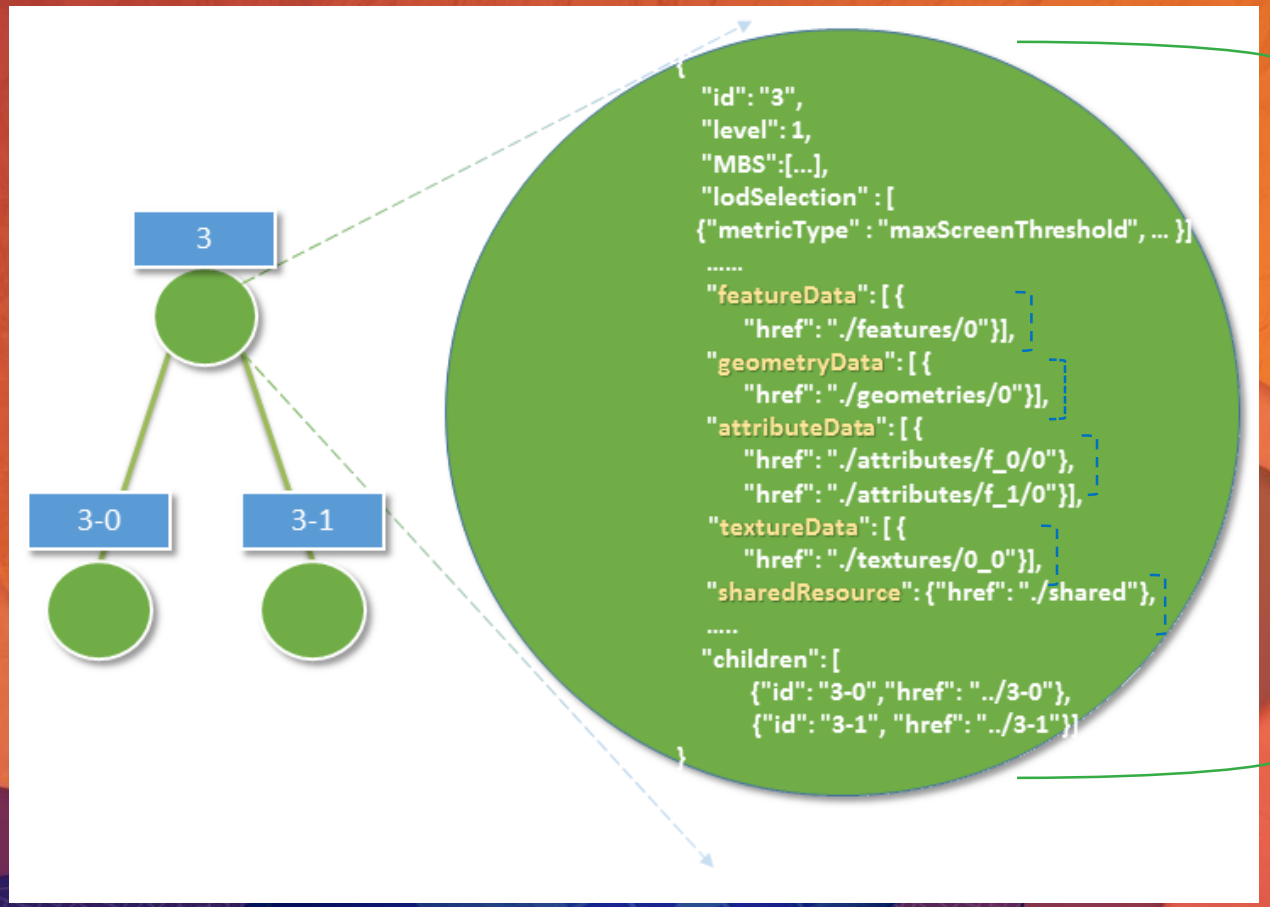
I3S: Organization and structure

- **Organizes geospatial data using a hierarchical, node-based spatial index structure**



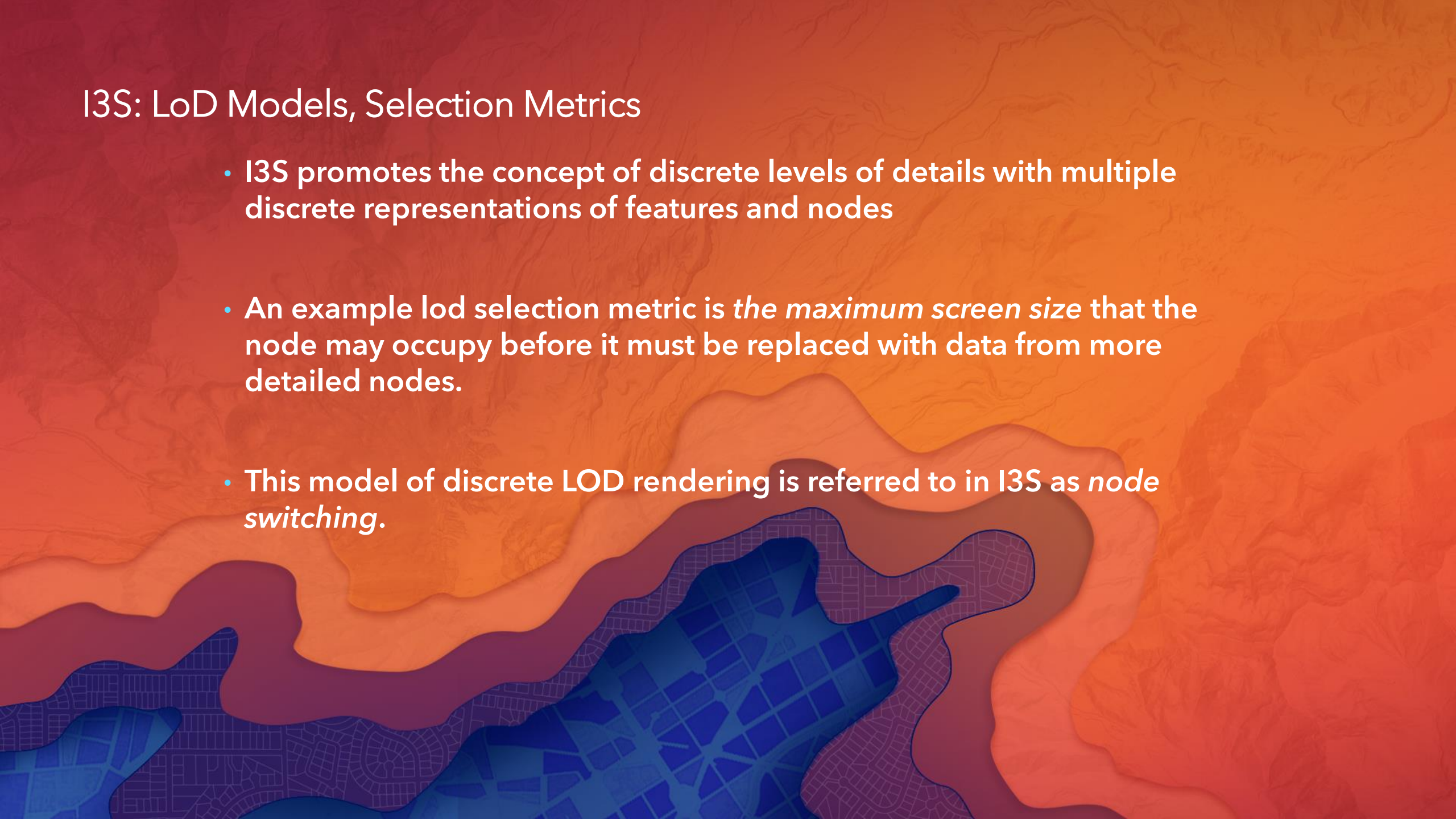
I3S: Organization and structure

The physical organization of information within node:



I3S: LoD Models, Selection Metrics

- I3S promotes the concept of discrete levels of details with multiple discrete representations of features and nodes
- An example lod selection metric is *the maximum screen size* that the node may occupy before it must be replaced with data from more detailed nodes.
- This model of discrete LOD rendering is referred to in I3S as *node switching*.



I3S: Consumption

- *As a service (via a REST API) or locally as a file system (SLPK)*

  - As RESTful interfaces/services:
    - Via a RESTful interface that exposes the scene layer, its nodes and their associated resources (geometries, attributes, textures) as web addressable resources.
      - I3S resources are designed for direct access (via a unique key) from key value based cloud blob stores such as Windows Azure Blob Storage or Amazon Simple Storage (S3) using built in REST APIs of such infrastructures
  - As a single large Scene Layer Package (SLPK):
    - A single file that packages the complete node tree and its resources into an archive that supports direct access to the individual nodes and resources within it.

I3S: Flexibility

- **Examples of I3S flexibility:**

- **Minimum Bounding Volume (MBV):**
  - Minimum Bounding Sphere (MBS)
  - Oriented Bounding Box (OBB)

- **The node structure may be**
  - 'expanded' – with complete meta-information about node's position and BVH topology
  - 'fixed-size' – in support of '*paged*' access pattern

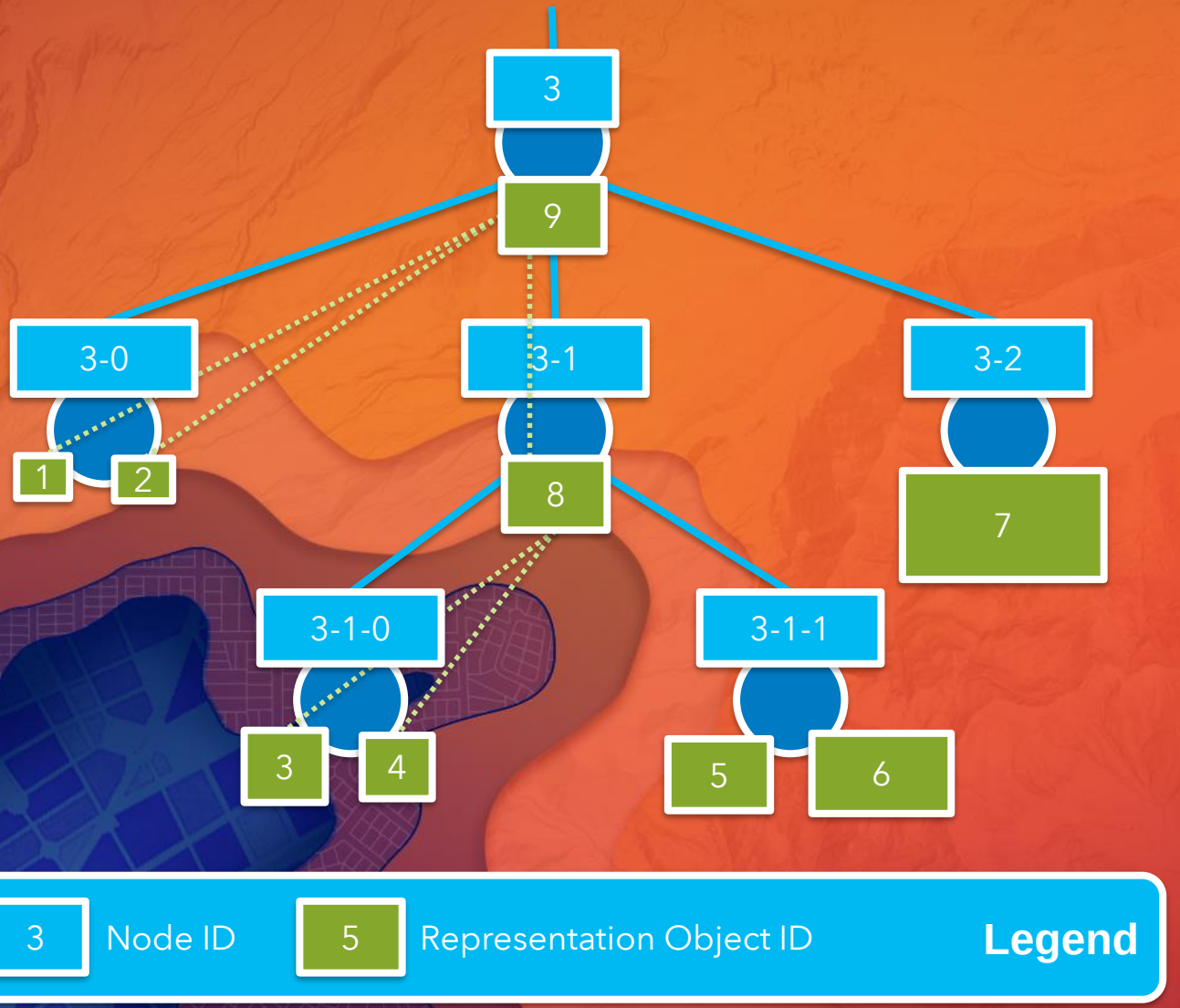
I3S: Flexibility (cont'd)

- Nodes may have "embedded" vs "binary" geometry/attribute content format
  - Embedded geometry: as JSON in-lined with additional metadata
  - Binary format: as typed array buffer views

- LOD Selection based on different metricTypes:
  - *maxScreenThreshold* – LOD switching based on screen 'size' of the node's MBV
  - *screenSpaceRelative* – LOD switching based on screen 'scale' of the node's MBV
  - *distancRangeFromDefaultCamera* – LOD switching based on normalized distance of the node's MBV from the camera
  - *effectiveDensity* – estimation of the point density covered by the node

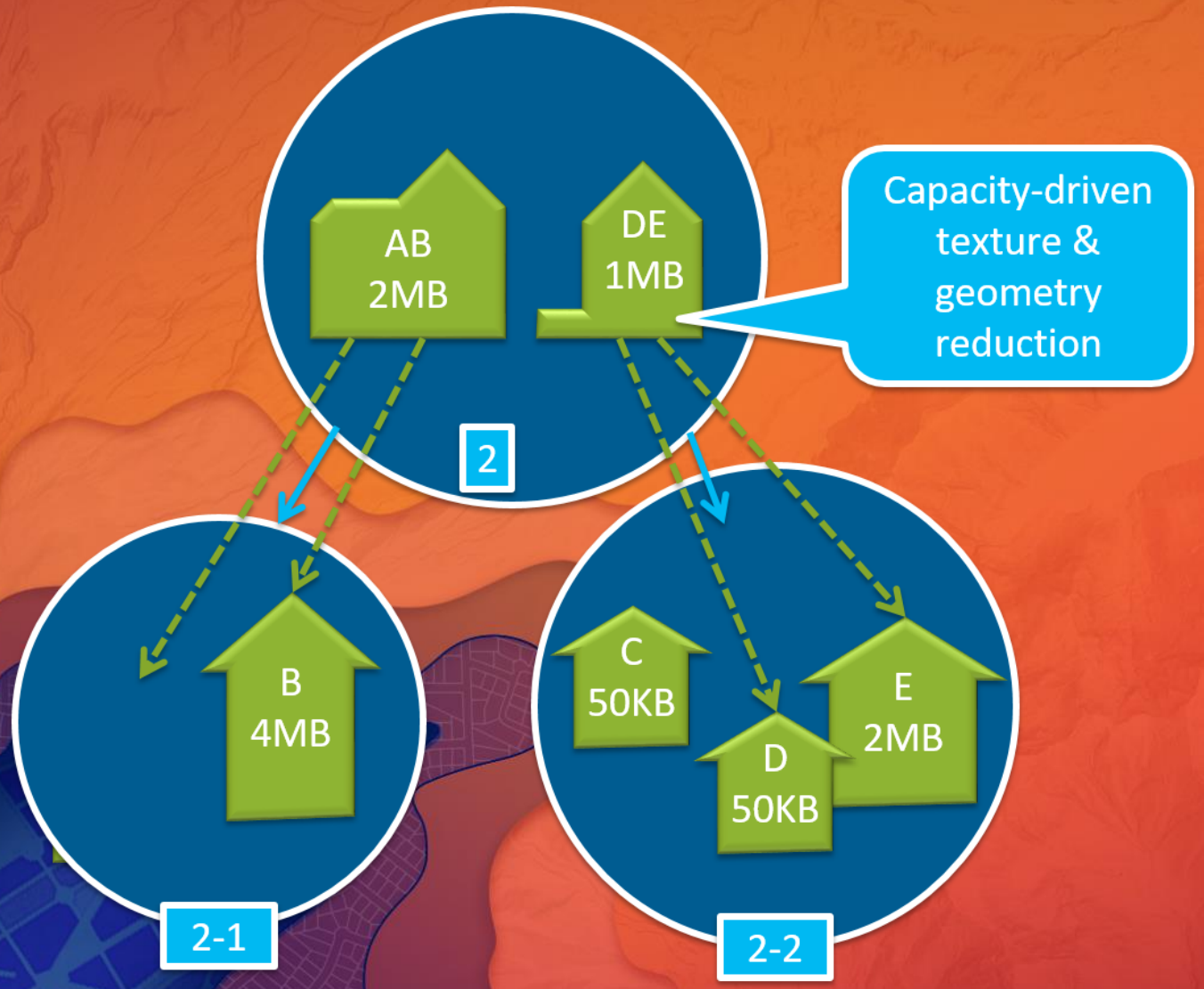
The Key to Scalability: Indexing

- **Adapt Index type to data**
  - R-Tree
  - Quadtree, Octtree
  - Standard Tiling Scheme
- **Load-Balanced**
  - Near-Constant Data Volume per Node

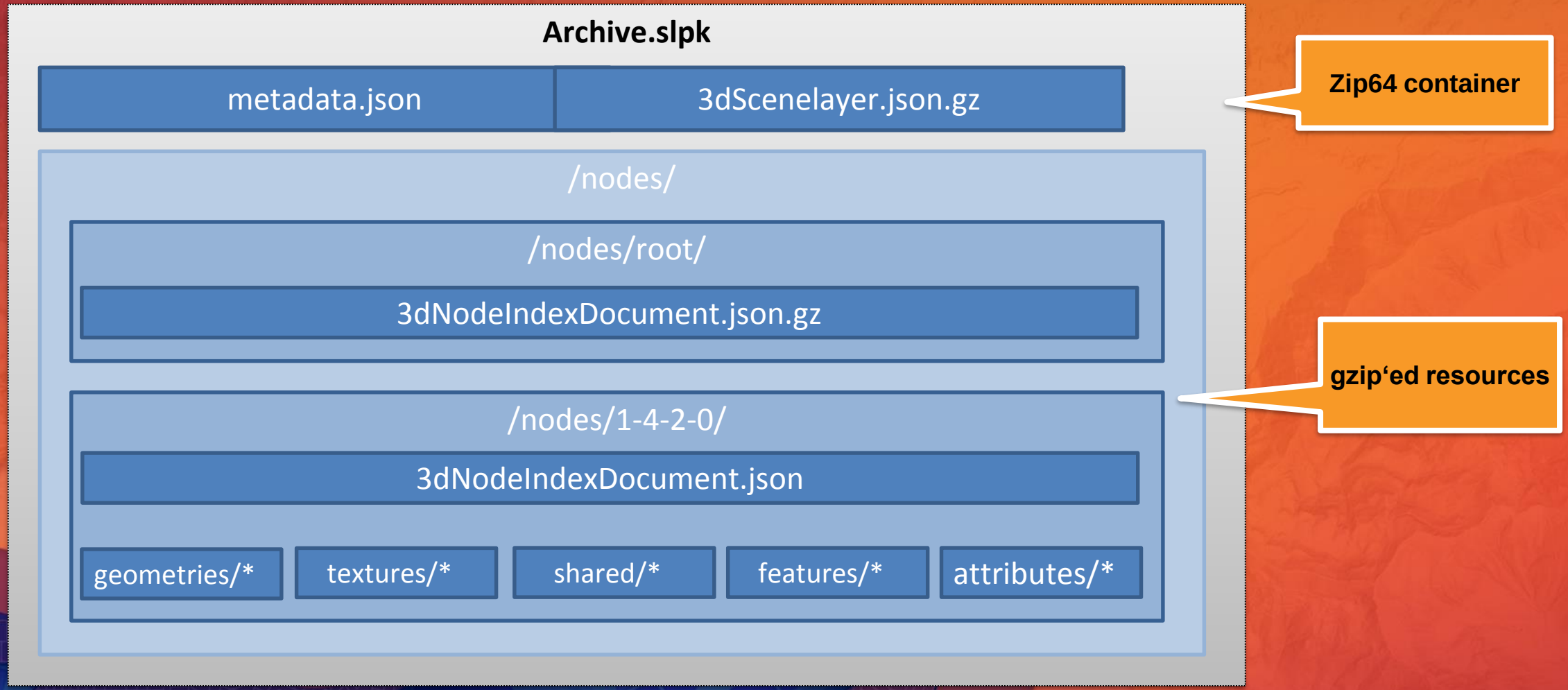


The Key to Scalability: Level of Detail

- **Node Switching LoD**
  - *Full Representation* Pyramid with a Node-based alternate representation
  - Use for:
    - Feature data lacking authored LODs
    - Homogeneous contextual data (Integrated Meshes)



Scene Layer Package (SLPK) and Scene Service REST API

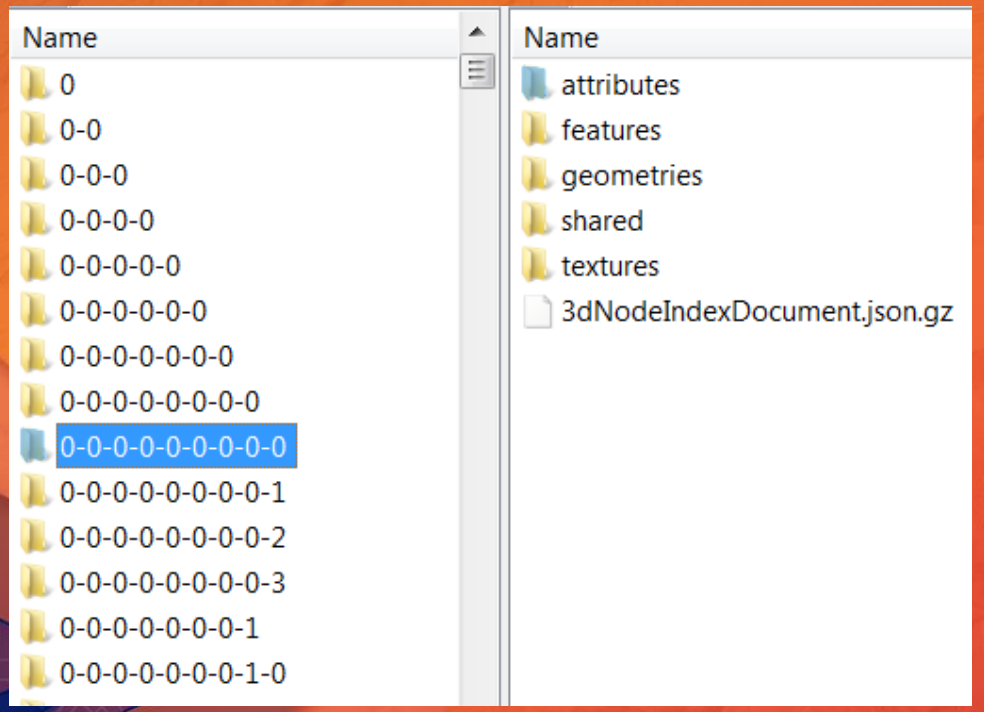


File System Folder Layout

Direct mapping of the REST API

- **All resources reside in the file system as individual files.**
- **These files are organized in folders in the following schema:**

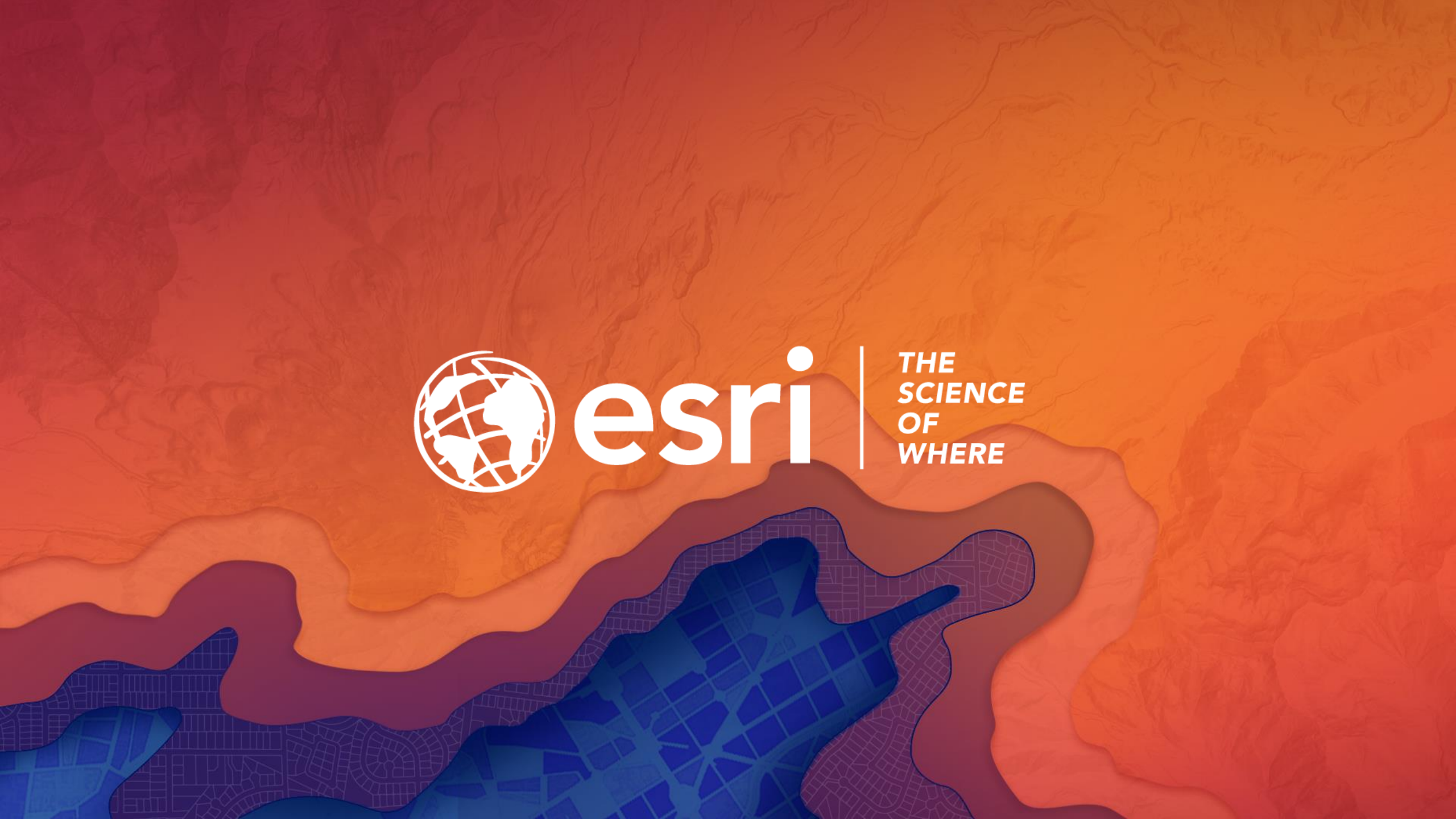
```
/3dSceneLayer.json
/nodes/<node-id>/3dNodeIndexDocument.json
/nodes/<node-id>/features/0.json ...n.json
/nodes/<node-id>/geometries/0.bin ...n.bin
/nodes/<node-id>/shared/SharedResource.json
/nodes/<node-id>/textures/0_0.bin ...n_m.bin
/nodes/<node-id>/attributes/0.bin ...n.bin
```



Declarative: Geometry buffer metadata

```
"defaultGeometrySchema": { // geometry resource layout for nodes that declare the use of defaultGeometrySchema in the node index.
    "header": [ // header fields that precede the vertex data
        {
            "property": "vertexCount", // vertex count
            "type": "UInt32"
        }
    ],
    "topology": "PerAttributeArray", // one of ["PerAttributeArray", "InterleavedArray", "Indexed"]. When "Indexed", the indices must also be declared in the geo
    "vertexAttributeOrder": ["position", "normal", "uv0", "region"], // provides the order of the keys in vertexAttributes.
    "vertexAttributes": { // the vertex attributes must appear in the order that they are declared here.
        "position": { // the name of the vertex attribute; here: vertex positions
            "valueType": "Float32", // the element type, either UInt8, UInt16, UInt32,  Int16, Int32, Int64 or *Float32*, Float64
            "valuesPerElement": 3  // number of (Float32) values need to make a valid element (here a xyz position)
        },
        "normal": { // the name of the vertex attribute; here: vertex normals
```

Header	Body		
vertexCount	vertexAttributes	*faceAttributes*	*featureAttributes*
faceCount	position	*position*	*id*
featureCount	uv0	*uv0*	*faceRange*
	normal	*normal*	
	color		


esri
THE SCIENCE OF WHERE