Lesson 4: Digital Infrastructure for enabling Geospatial Knowledge Services

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Digital infrastructure provides foundational services that are necessary to the information technology capabilities of a nation, region, city or organization.

In the context of GKI, digital infrastructure provides the underlying digital backbone to effectively make use of the GeoSpatial Knowledge for improving the economy and quality of life of a modern nation.

- Concepts of data centers, platforms, and systems required for enabling GKI
- Cloud computing and how it enables GKI
- Spatial data infrastructure and transformation from data to knowledge
- Applications, APIs, Integration, standards for GKI

Goal is to enable solutions that can be replicated for everyone
Elements of GKI

- Geospatial Knowledge at the heart of tomorrow's global digital society
- Integrated Policy Framework
- Foundation Data
- Partnerships and Collaboration
- Industry Leadership
- Applications, Analytics and Modelling
- Geospatial Dimension to the Wider Digital Ecosystem
Modern Digital Infrastructure

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Security, Observability and Management, Compliance

Cloud Data Center Infrastructure
How do the elements of GKI map to the cloud infrastructure

**These should be part of infrastructure

**These should be enabled by the infrastructure
Three Classes of Cloud Services

Software as a Service
- Hosted Applications, Services
- Development tools, databases, Business analytics
- Operating Systems

Platform as a Service

Infrastructure as a Service
- Servers Storage
- Datacenter Networking
Cloud Computing Basics

On-demand self-service
Broad network access
Resource pooling
Rapid elasticity
Measured service

And there are three basic cloud deployment models:

Public » Private » Hybrid
Examples of services: Infrastructure as a Service

- The popular compute and storage services from Amazon, Google, Microsoft, etc. are examples of IaaS
- Usually includes Linux/windows servers with storage
- Everything we need for GKI will be built on these platforms
Examples of services: Platform as a Service

- Databases, Middleware servers, Java and other runtime environments
- Apache Hadoop and Spark platforms
- IoT stream processing
- Docker and container Engines
Examples of services: Software as a Service

- Google Maps is one of the most widely used SaaS
- Financial and CRM applications
- IoT stream analytics
- HR applications
Digital Infrastructure for GKI
First look at a mapping of the GKI elements to PaaS and SaaS
Spatial data infrastructure

- Let us start with Data and how cloud infrastructure makes it easy to share and publish data sets
- The previous generation systems suffered from data silos due to organizational silos
- Sharing of data between departments and organizations was hard as data ownership issues, physical copies of data in local systems, non-standard and ad hoc methods for publishing data
- At the organization level, all departments use the same cloud, this makes it easier to share the data across all departments of the organization
- But raw data can only go so far in solving problems
- Data should be published using standard interfaces and web services
- Built in adopters for collecting data from sensors (LiDAR, mobile devices) as part of the cloud platform
The geospatial community today and tomorrow

- Data-centric
  - Centralized system
  - Desktop/web-portal
  - 2D representation
  - Supply-centric
  - Static data
  - Limited data range
  - Professional users only
  - Linear and independent
  - Government

- Spatial Data Infrastructure

- Geospatial Knowledge Infrastructure
  - Analytics-centric (fit for analytics data)
  - Distributed system
  - Distributed cloud-based
  - 4D/5D representation
  - Demand-centric (user-centric)
  - Dynamic data with wide range of data (crowdsourced, mobile, IoT, etc.)
  - Non-spatial users as well
  - Intelligent search
  - On-the-fly data analysis
  - Predictive modeling
  - Government, industry and citizens
Spatial Data Services
ETL, Data Validation, and Enrichment

Load and Spatial data prep
Addresses Coordinates → Augment with geometry and spatial index

Validation and Correction
Raw spatial data → Geometry error detection, correction

Enrichment
Locations → Augment with demographics.....
Data Services in the context of GKI

Content
contextual layers
- POIs
- Admin boundaries
- Traffic Patterns
- Elevation
- Climate data
  ...

Feeds
Real-time layers
- traffic
- weather
  ...

Enrichment
augment attributes
- Demographics
- Behavior
- Mobility
- Housing
- Financial
  ...

Combine these data sources to provide knowledge services
For example, combine climate data, weather data to build crop prediction models
Search service on the knowledge

• Traditional data services (catalogue services) let you search for data sets
  • The search needs to be inverted from what we traditionally do
• Need a service that lets you find the relevant data sets corresponding to problems
• Don’t search for specific data sets: find me rainfall data for this location
• Search for knowledge: I want to model weather pattern for this crop season, show me what data sets I can use or show me existing services I can use to build a solution
Custom Spatial Services

Native Applications

- Geocoding/Routing
  Locate addresses and optimized routing

- Asset Tracking
  Monitor locations of moving assets and relationships to point of interest

- Geofencing
  Monitor movement of assets in/out of areas of interest

- Geo-Enrichment
  Enrich locations of interest with demographics and other info

- Realtime Traffic/Weather
  Traffic/Weather feeds for overlays and alerts

Developer Services

- Spatial Analytics
- ETL and Validation
- Data Service
- Map Publishing
- Map Authoring

- Spatial Visualizations
- Spatial AI
- Real-time Spatial Analytics
- IoT Integration
- Standard Web Services
Rich Data Visualizations
Spatial Analytics

Analysis REST services Examples

- Identify nearest item
- Identify items within a distance
- Identify items inside/outside of a region
- Determine distances between items
GeoSpatial AI Platform

- Solar Potential scoring
- Detect Urban growth
- Site Selection
- Consumer Profiling
- Tree cover growth using Point Clouds
- Portfolio Risk Analysis
- Urban Planning
- Hotspot Prediction
Access to technology is enabled with the cloud infrastructure

• A prime example is AI/ML algorithms, models, training data sets
• For example, there will be systems that provide classification as a service
  • Take user data as input and use the predefined AI models and training data and classify the user data
  • Eg. Take arial photographs from a local government and identify new constructions, swimming pools, vegetation, etc.
  • Local governments don’t need to invest in data scientists but use these cloud services
• Training machine learning models is CPU intensive, and traditionally this investment is too expensive for many organizations
  • With metered GPU services, organizations can now train models using GPUs without the investment to build up these resources
Self service and low code environments

- Cloud infrastructure encourages low code environments for application development by providing common services on the platform
  - Low code environments set a low bar of entry for application users to modify and customize applications
  - Cloud native applications also encourage self service environments
    - Self service applications provide easy to use interfaces and UI driven workflows with built in error correction models to let non specialists use the applications
  - These are game changing directions for newer technologies; users don’t need to understand how the technology works to use the systems built on these technologies
    - You don’t need to be a data scientist to use a machine learning model to identify urban growth using satellite imagery
Applications, APIs, Integration, standards for GKI

• Cloud native applications are built with easy to web service APIs
• Geo-spatial standards provide the necessary definitions for commonly used services
• When applications are built with these open web service standards, lot of roadblocks people encounter integrating different applications are removed
For example, REST APIs for spatial analytics will fall under developer services.
Where do we want to be in 5 years?

Software as a Service

Platform as a Service

Infrastructure as a Service

Hosted Applications, Services

Development tools, databases, Business analytics

Operating Systems

Servers Storage

Datacenter Networking