U.S. Department of the Interior

Interior Enterprise Architecture

Chapter 5
Geospatial Technologies Architecture
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Chapter 5. Geospatial Technologies Architecture

5.1 Introduction and Background

Of all the Departments within the Federal government, the Department of the Interior (DOI) is arguably the one most closely tied to the land. Most of the resources that the department is chartered with managing and protecting are geographic in nature (e.g., National Parks, Mineral Resources.) Within the Information Technology portfolio of services, Geospatial technologies, also, are the most focused upon the land.

The heart of Geospatial technologies is concerned with geographically referenced data and identifying spatially defined relationships. Specifically, the data has either an explicit geographic reference, such as latitude and longitude coordinates, or an implicit reference such as an address, postal code, forest stand identifier, or road name. From the creation of maps to the analysis of potential flooding from a hurricane, geospatial information is used for many and various purposes; both within Interior as well as by our many outside partners (e.g., other Federal agencies, State and Tribal Governments and the public at large).

But Geospatial technologies are much more than making maps. It allows users to access, examine, and analyze geographically referenced information and identify spatially-defined relationships. Traditional information technology or manual methods of mapping and data analysis are severely limited when compared to Geospatial technologies. Simply put, Geospatial technologies extend our reach and our ability to use complex information about the land and its resources to simplify those complexities via Geospatial models and the visualization representation of the natural systems that the data represents. Geospatial technology software has the ability not only to store graphic representations of map features but also to access diverse types of data and records that have a geographic component.

The focus of the Interior Enterprise Architecture is on providing guidance for IT issues and initiatives that are Interior-wide or multi-bureau in scope. The Geospatial technologies architecture defines the technologies, standards and guidelines that relate to the use and sharing of data that can be referenced geographically. It includes any mapping activities such as geographic information systems (GIS), global positioning systems (GPS), aerial photography, surveyor data, remote sensing & imaging (e.g., satellite), planetary GIS, spatial modeling, visualization, Geospatial mapping products of Computer Aided Drafting/Design (CAD), and “any data tied to a location”.

If used correctly, the Interior Enterprise Architecture will act as a catalyst for those looking to capitalize on its contents and better understand the full meaning of its guidance. This understanding will permit IT personnel to better engage the non-IT organization in discussions around tradeoffs and priorities within the proper governance structure (e.g., Management Initiatives Team (MIT), Information Technology Management Council (ITMC)). The Interior Enterprise Architecture is not intended to be the “last word” (e.g., some automated checklist for product selection). It is intended to be one of the “first words” to assure that Interior’s mission priorities and its IT priorities remain closely aligned.

Additionally, it's doubtful that a single Technical Reference Model (TRM) domain chapter can be used to address a substantive issue. More realistically, a few architecture domains may need to be reviewed when addressing an important IT decision. For example, if Interior was considering the creation of a new Interior-wide Geospatial technology mapping capability that could be used both by the general public and Interior personnel, then the TRM chapters like Geospatial Technologies, Information Security, Application Development, and Web/E-Government might all need to be reviewed.

The Geospatial technology components in this domain include:

- Geospatial Software - the functions and tools needed to store, analyze, and display information;
- Application development tools - tools for the creation and acquisition of based-based technology solutions;
- Spatial database engines- products that are designed to work with geographically referenced data;
- Databases - programs that control the organization, storage and retrieval of data;
- Modeling tools – software that creates digital representations of business processes and data;
- Administrative tools - software that addresses various back-end processes.

5.2 Architectural Principles

The principles listed below provide guidance for the design and selection of technology components that will support the Geospatial technology needs of Interior-wide IT initiatives.

Principle 1: Spatial components

Most data within Interior has a Geospatial component; our databases must reflect that fact.

Rationale:

- DOI is a geographically based organization.
- Better communications and decision-making can be made through the visualization of complex information.
- Geospatial information adds significant value to data.
- Geospatial technology is the information tool for geographic enterprises.

Implications:

1. Adding Geospatial components to legacy data may be expensive.
2. Need common business model for relational database (e.g., keys, data content, definitions).

3. Need training for developers (both Geospatial and non- Geospatial knowledgeable) on using geospatial information.
4. Applications must not remove geospatial references during processing.
5. Need for Geospatial reference review during system development process.

Principle 2: Information is an Interior asset

Information is valued as an Interior asset to accelerate decision-making, improve management, and increase accountability.

Rationale:

- The value of information is not realized if it is held in isolated pockets.
- Information must be shared to maximize effective decision-making across lines of business and with partners.
- Information is necessary for decision making to support accelerated business process cycles.
- Increased access leads to improved integrity and relevance of data.
- Supports Office of Management and Budget (OMB) Circulars: A16 "Coordination of Surveying, Mapping and Related Spatial Data Activities"; A-119 "Federal Participation in the Development and Use of Voluntary Standards"; and A-130 "Management of Federal Information Resources".
- Supports Executive Order 12906 "Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure".

Implications:

1. Supporting policies regarding security, privacy, confidentiality, information sharing, information integrity, utility and data relevance must be developed and implemented (e.g., as outlined in FGDC Privacy Act - Newsletter Summer 1998; see: http://www.fgdc.gov/publications/documents/geninfo/fgdcnl798.html).
2. Need to promote interoperable information management, such as data warehouses and data access methods that facilitate information availability for decision-making.
3. Data warehouses, metadata and data accesses may need to be developed to facilitate information availability for decision-making.
4. Information needs to be structured for easy access and management, timely availability, and use.
5. Metadata (information about the data, such as source, units of measurement, and collection methods) will need to be developed and made available.

6. Need regular training on appropriate use of information and its quality (e.g., refuge vs legal vs legislative boundaries).
7. Need to maintain currency of the data and the legacy data itself.
8. Need to assure the accuracy and accessibility of the data over time (e.g., mapping historical changes and maintaining it like wetlands).
9. Need a method for estimating the value of the information assets themselves (e.g., specific Geospatial database is valued at $50M because it would cost that much to recreate it).

Principle 3: Data and Information Stewardship

Data and information must be managed and maintained as a stewardship responsibility to support the mission of Interior.

Rationale:

- Data is a resource important to the accomplishment of Interior's work. In its broadest sense, it is information including items like electronic and paper documents (e.g., maps), emails, film, etc. Like natural resources, data needs stewards who are responsible for its valuation, preservation, security, access and utilization across Interior and with the public.

- Data stewards will promote common business rules, which would facilitate information sharing, communication, and improved data integrity.

- Supports Office of Management and Budget (OMB) Circulars: A16 "Coordination of Surveying, Mapping and Related Spatial Data Activities"; A-119 "Federal Participation in the Development and Use of Voluntary Standards"; and A-130 "Management of Federal Information Resources".

- Supports Executive Order 12906 "Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure".

Implications:

1. Recognition that business area personnel need to be responsible for stewardship of the data and the commitment of the resources necessary to make stewardship happen.
2. Stewardship includes responsibility for clarification of the data's meaning, content, and reuse.
3. Stewardship includes responsibility for managing data's consistency, timeliness, accuracy and completeness.
4. The scope of stewardship must be very sensitive to the sources and uses of the information, ensuring security, confidentiality and privacy are protected.
5. Need to develop a data stewardship program that will transcend many organizational boundaries (e.g., no current rewards for cross-bureau

cooperation) and include various levels of stewardship while leveraging and adhering to Federal data programs and standards (e.g., Federal Geographic Data Committee (FGDC), National Institute of Standards and Technology (NIST)).
6. Recognition of the need to manage metadata; that is data "about" the data.
7. Responsibility of steward for training and education in a persistent and consistent manner (e.g., software, data, and methodology changes regularly).

Principle 4: Integration/ Interoperability

Systems must be designed, acquired, developed, or enhanced such that data and processes can be effectively shared, for appropriate purposes, across Interior and with our partners.

Rationale:

- Increased efficiency will better serve our customers (e.g., the public, employees).
- Duplication of effort will cause higher support costs.
- Ensures more accurate information.
- Shared data and processes lead to better decision-making and accountability.
- OMB Circular A16 "Coordination of Surveying, Mapping and Related Spatial Data Activities".

Implications:

1. Will need common data standards and consistent data management processes across Interior.
2. Every systems analyst needs to consider enterprise wide impacts when designing enhancing, acquiring or extending the scope or use of applications.
3. We will need new tools that enable data sharing and the training for their proper use.
4. Will need a method for identifying data and processes that need integration, when integration should take place, the degree of integration versus interoperability, who should have access to the data, and cost justification for integration.
5. Over-integration can lead to difficult data management and inefficient processes.

Principle 5: Reuse before you buy and buy before you build

In considering system requirements (e.g., new functionality), we should look to reuse existing components before we buy. If no components exist, purchased solutions (e.g., commercial-off-the-shelf (COTS) or government-off-the-shelf (GOTS)) should be explored before we build.

Rationale:

- Complies with, the Privacy Act of 1974 and the Government Information Systems Reform Act (GISRA).
- Supports Office of Management and Budget (OMB) Circulars: A16 "Coordination of Surveying, Mapping and Related Spatial Data Activities"; A-119 "Federal Participation in the Development and Use of Voluntary Standards"; and A-130 "Management of Federal Information Resources".
- The more you're "like" everyone else (e.g., same standard, same systems), the easier it is to share with others.
- System development is not a primary mission of Interior.
- Supports Executive Order 12906 "Coordinating Geographic Data Acquisition and Access: The National Spatial Data Infrastructure".

Implications:

1. Need to define, identify and maintain "reusable" components.
2. Good system specifications will be needed early in the planning cycle to evaluate alternatives.
3. Business processes may need to be "changed" but not compromised to ensure compliance with Interior and Federal standards, to accommodate reuse or purchased solutions.
4. In-depth knowledge of system functions may be outside of the organization, potentially increasing issues of risk and cost. Therefore, it will require the metadata information like the process, references (e.g., algorithms), and documentation (e.g., 50% of programming code is remarks) as well as acquiring the digitally delivered unencrypted original source code from the software vendor.
5. Requirement for greater sensitivity to the possibility of losing mission responsibility when using outside resources.
6. System design will migrate to "open" standards.
7. When acquiring data from private vendors, licensing restrictions should be considered.

Principle 6: Enterprise Network as "Virtual" LAN

We must implement an Interior-wide "interoperable network"; performing as if it were a virtual, Interior-wide Local Area Network (LAN).

Rationale:

- Networks are the essential enabling technology for client/server, Internet, and collaborative computing (e.g., emails, file transfers (e.g., file transfer protocol (FTP)), secure teleconferencing, workflow, geospatial data).
- Knowledge workers have increasing need for access to information across Interior; this access must appear seamless.
- Lack of a robust network architecture will impact the success of distributed applications.
- Expands the vision of organizations by reaching out to customers and suppliers.

Implications:

1. Requires higher speed and higher bandwidth networks.
2. Will need the interconnection of distributed LANs.
3. Need to create connections between legacy systems, client/server and Internet applications.
4. Need to implement a robust, interoperable directory services capability.
5. Need to define guidelines around "who pays", "who uses", "who gets", and "who coordinates" these interoperable networks.
6. Policies and protocols on sharing and exchanging information with third parties need to be addressed (e.g., restricted sub-nets will need to be supported).
7. Need to accommodate remote locations with limited communications options.

Principle 7: Information Access

Easy and timely access to data and information is the rule rather than the exception without security, confidentiality, and privacy being compromised.

Rationale:

- Productivity, decision-making, and customer service all benefit from easy, direct, and timely availability of information.
- In accordance with the Paperwork Reduction Act (PRA, PL 104-13), employees and the public should have efficient, effective, and economical access to Government information.
- Information should be attainable in the appropriate place, time, format and context.

- The Rehabilitation Act of 1998 requires executive agencies to develop, acquire and use information technology that is accessible to individuals with disabilities.

- Under Electronic Freedom of Information Act (E-FOIA) bureaus and offices are required to make records that are frequently requested under the FOIA available for public inspection. Further, records created on or after November 1, 1996 must be available via the Internet or other electronic means.

- The Government Paperwork Elimination Act (GPEA) requires agencies to incorporate privacy protections when developing electronic processes.

- Beyond the legal requirements, easy and timely access to data and information makes sound business sense.

Implications:

1. Need to identify, publish and keep the applicable policies and attendant interpretations current.
2. For unclassified information, the right to know should be presumed unless policy or law specify otherwise; however, for information like "pre-decisional information", access would still be controlled.
3. The business necessity of sharing information must be established.
4. Technology must be deployed to distribute and allow access to information.
5. Classification and sensitivity of information must be clearly stated and the rules well defined (e.g., locational precision protected where an archeologically significant site or a nuclear power plant is located.)
6. Sensitive information must not be accidentally released (e.g., copyright.)
7. A variety of public and private access methods for public information in accordance with E-FOIA will need to be provided.
8. Every attempt will be made to make information available in formats accessible to those with sensory disabilities in accordance with Section 508 without incurring an undue burden.

Principle 8: Reengineer First

Business processes will be analyzed, simplified or otherwise redesigned in preparation for and during information systems enhancements, development, and implementation.

Rationale:

- Work processes will be streamlined, efficient, and cost-effective.

- Work processes, activities, and associated business rules will be well understood and documented.

- Enables E-Government initiatives.
- Potentially reduces the total cost of ownership.
- Provides better customer service.
- Required by Clinger-Cohen and OMB Circular A-130 "Management of Federal Information Resources" before an IT investment can be made, and promotes compliance with the Government Performance and Results Act (GPRA).

Implications:

1. Cultural change may be required to implement reengineered business processes that include geospatial technologies.
2. Need system sponsors to include the impact of geospatial data on their goals.
3. Need for system owners and developers to understand that visualization can be used as a starting point for initial systems analysis and understanding complex processes.
4. Need agreed upon business process re-engineering scope and results to enable continual improvement through analyzing, simplifying and redesigning work processes.
5. New technology will need to be researched and applied in conjunction with business process review (e.g., don't use "new" just because it's new).
6. Additional time and resources will have to be invested in business analysis early in the systems life cycle.
7. Requires all organizational levels, especially senior leadership to sponsor and support reengineering efforts.
8. Need training for developers (both Geospatial and Non-Geospatial knowledgeable) on using geospatial information.

Principle 9: Total Cost of Ownership

Interior will adopt a total cost of ownership model (TCO) for IT systems that includes costs like data acquisition and maintenance (e.g., biggest costs of Geospatial elements).

Rationale:

- Leads to better-informed decisions through an improved understanding of trade offs.
- Enables improved planning and budget decision-making.

Implications:

1. For Geospatial solutions, the data sets have their own life cycle in addition to the software itself (i.e., data is major cost driver with requirements like compliance that add to expense).
2. Geospatial data never really "goes away" so maintenance is high (e.g., 9 track tape of satellite data needs to migrate to new media).
3. Need for coordinated management to mitigate data maintenance cost (e.g., National Spatial Data Infrastructure (NSDI) framework data sets)
4. Need to develop a total cost of ownership model that explicitly includes geospatial data management and educate system sponsors and decision-makers about how to use it.
5. Leads to coordinated system replacements, enhancements and retirements.
6. Need to apply TCO to portfolio management and records management (e.g., geospatial data sets and hardcopy are part of the data).
7. Need to provide tools for collection of the actual total cost of ownership.

Principle 10: Mainstream Technologies

IT solutions will use industry-proven and "state-of-the-art" mainstream technologies.

Rationale:

Avoids dependence on weak vendors.

- Ensures robust product support.
- Enables greater use of commercial-off-the-shelf solutions.
- Complies with OMB Circular A-130 "Management of Federal Information Resources", which requires the application of up-to-date information technology to take advantage of opportunities to promote fundamental changes in agency structures, work processes, and ways of interacting with the public that improve the effectiveness and efficiency of Federal agencies.

Implications:

1. Need to establish criteria for vendor selection and performance measurement.
2. Need to establish the criteria to identify the weak vendors and poor technology solutions in compliance with Federal government contracting policy and procedures.
3. Requires the technology portfolio to migrate away from existing weak products or products that are reaching obsolescence.
4. We may be slow to adopt new technologies.
5. The exploration of new technology will be managed and investigation

results shared.
6. Changing from mainstream vendor's products within Geospatial technologies will incur significant conversion costs (e.g., maintenance of existing geospatial legacy data) and loss of support for our partners (e.g., other agencies, customers).
7. Conversions may result in explicit loss of data (e.g., Michigan project with 2-5% of the data content was lost due to a format change).

Principle 11: Industry Standards

Extra value will be given to products adhering to industry standards and open architecture.

Rationale:

- Required to support data and process interoperability.
- Reduces risks.
- Reduces dependence on single vendor.
- Enables greater use of commercial-off-the-shelf solutions.
- Allows flexibility and adaptability in product enhancement, extensibility, and replacement.

Implications:

1. Need for Interior-wide core standards for exchanging geospatial data among bureaus.
2. Need effective management process to identify and assess industry standards and share standards information across Interior.
3. Participation in the development of open standards is mandatory.
4. Training and education are required to promote the use of "open standards."
5. Public open standards will need to be used for distribution of geospatial data to "outside" participants (e.g., public) to avoid proprietary formats.

5.3 Technology Components

There are two underlying assumptions to the Geospatial Technologies Architecture. First, if there is a need to evaluate various type-type peripherals (e.g., scanners, plotters, digitizing tablets, workstations, printers, remote sensing devices, etc.), the interested person will contact the appropriate Geospatial personnel within their respective organization. There was no attempt to classify the many peripherals available for use by Geospatial technology applications. The second assumption is that the technology solutions reviewed would be those used by 80-90% of the people within Interior. The team recognized that other solutions exist (e.g., Open Source tools).

The classifications for any products or standards within this domain are:

Life Cycle Classifications	Definition/ Meaning
Preferred	Product/standard of choice; support available; recommended.
Contained	Develop solutions using these standards or products only if there are no suitable alternatives categorized as preferred; if a preferred product is available that will meet the requirements, plans should be developed to move from contained to preferred as soon as practical.
Obsolete	Being phased out; (e.g., vendor support ending); plans should be developed to rapidly phase out and replace (often to avoid substantial risks).
Research	Product/standard to be used in conjunction with technology research efforts only (e.g., testing, pilots).
Rejected	Product/standard has been evaluated and found not to meet technical architecture needs.

5.3.1 Geospatial Technology Software

Geospatial technology software provides the functions and tools needed to store, analyze, and display information about places. Additional subcomponents of this technology are: 1) Internet Map Services (IMS) which provide interactive maps for publishing on the Internet; and 2) Remote Sensing capabilities which make imaging information for analysis more useful because it contains more than simple pixel information.

Geospatial technology software:

- Use of the ESRI Suite of Tools is classified as **Preferred**.
- Use of AutoDesk suite (Geospatial aspects) is classified as **Contained**.
- Use of Intergraph suite (Geospatial aspects) is classified as **Contained**.
- Use of MapInfo suite is classified as **Contained**.

IMS:

- Use of the ESRI Suite of Tools is classified as **Preferred**.

- Use of Intergraph is classified as **Preferred**.
- Use of MapInfo is classified as **Preferred**.
- Use of AutoDesk is classified as **Preferred**.

Remote Sensing Tools:

- Use of ERDAS Imagine is classified as **Preferred**.
- Use of PCI Geomatics is classified as **Preferred**.
- Use of Research Systems ENVI is classified as **Preferred**.

5.3.2 Application development tools

Application development tools allow for the creation and support of based-based technology solutions that support business information needs. By using common development tools, the benefits of interoperability, scalability and reusability of many IT components can be provided to all of Interior. Within this technology component are languages and various utilities.

Languages:

- Use of C is classified as **Contained**.
- Use of C++ is classified as **Preferred**.
- Use of Microsoft Visual Basic is classified as **Preferred**.
- Use of Sun JAVA is classified as **Preferred**.
- Use of CAD Languages is classified as **Contained.**
- Use of ESRI Languages is classified as **Contained**.
- Use of FORTRAN (Formulate Translation) is classified as **Contained**.

Utilities:

- Use of PERL is classified as **Preferred**.
- Use of Python is classified as **Preferred**.

Web Utilities:

- Use of Macromedia Cold Fusion is classified as **Contained**.
- Use of Sun JSP, Java Server Pages, is classified as **Preferred**.
- Use of XML, Extensible Markup Language, is classified as **Preferred**.

Other:

- Use of Javascripts is classified as **Preferred**.

5.3.3 Spatial database engines

Geospatial technologies store information about the world as a collection of themed layers that can be used together. A layer can be anything that contains similar features such as customers, buildings, streets, lakes, or postal codes. This data contains either an explicit geographic reference, such as latitude and longitude coordinates, or an implicit reference such as an address, postal code, census tract name, forest stand identifier, or road name. To facilitate access to this information, there are Geospatial technology specific products called spatial database engines that are designed to work with these geographic references.

- Use of Access (Jet Engine) is classified as **Preferred**.
- Use of ArcSDE, Spatial Database Engine, is classified as **Preferred**.
- Use of Informix Spatial Data Blade is classified as **Preferred**.
- Use of Oracle Spatial is classified as **Preferred**.
- Use of Arc Librarian (first generation ESRI file manager) is classified as **Contained**.
- Use of Finder is classified as **Contained**.

5.3.4 Databases

To provide the benefits of geospatial information, the backbone technology component is the traditional IT relational database management system (RDBMS). A RDBMS is an extremely complex set of software programs that controls the organization, storage and retrieval of data (fields, records and files) in a database. It also controls the security and integrity of that database. The RDBMS accepts requests for data from various application

programs and instructs the operating system to transfer the appropriate data. The ability of these databases to easily and quickly find, update and report geospatial information is critical to the successful use of Geospatial technologies.

- Use of Informix Dynamic Server is classified as **Preferred**.
- Use of Microsoft Access is classified as **Preferred**.
- Use of Microsoft SQL Server is classified as **Preferred**.
- Use of Oracle 9*i* is classified as **Preferred**.
- Use of D-Base (DBF Structure) is classified as **Contained**.
- Use of ESRI INFO is classified as **Contained**.
- Use of Ingres Enterprise Relational Database is classified as **Contained**.
- Use of Sybase Adaptive Server is classified as **Contained**.

5.3.5 Modeling tools

Modeling tools encompass software that permits the representation of business processes and data (e.g., universal modeling language (UML)). This modeling assists in the development of more robust applications. This Geospatial technology component also includes translators/ interpreters that take data from one type of Geospatial technology application to another while maintaining the data's topology (e.g., geometric construct of the data set).

Translators/Interpreters:

- Use of ESRI is classified as **Preferred**.
- Use of AutoDesk suite (Geospatial aspects) is classified as **Contained**.
- Use of Intergraph suite (Geospatial aspects) is classified as **Contained**.
- Use of MapInfo is classified as **Contained**.

Modeling:

- Use of UML is classified as **Preferred**.

5.3.6 Administrative tools

Administrative tools include software that addresses various back-end processes to assist Geospatial technology applications and users. These processes include cataloging (e.g., metadata creation, clearinghouse nodes, data warehousing) as well as data compression and data exchange.

Cataloging:

- Use of ESRI suite is classified as **Preferred**.
- Use of Intergraph SMMS is classified as **Preferred**.
- Use of NSDI tools is classified as **Preferred**.
- Use of Blue Angel Metastar is classified as **Contained**.

Compression Tools:

- Use of LizardTech tools is classified as **Preferred**.

Data Exchange Formats:

- For internal data exchange, the use of the ESRI Suite of formats is classified as **Preferred**.
- For external data exchange, the use of the non-proprietary formats is classified as **Preferred**.

5.4 Select Best Practices

The Domain Principles, because they are derived from Interior's business direction and strategies, provide the primary direction and guidance around technology decisions within this domain. Additional benefit may sometimes be obtained by reviewing Select Best Practices. These reflect the valuable insights from either domain team members' experiences or other public sector organizations.

Select Best Practice 1: **Analyze the types of geospatial users. –** When providing geospatial technology to a large user base, consider the requirements of the end users very carefully (e.g., sophisticated analysts versus casual users).

Select Best Practice 2: **Create a portal. –** Develop a Geospatial data portal for access to Interior's enterprise-wide geospatial data.

Select Best Practice 3: **Create/hire trained Geospatial/ IT specialists. –** Train Geospatial technology/IT specialists to support geospatial technologies.

Select Best Practice 4: **Increase awareness of geospatial technologies Interior-wide. –** All parts of Interior's organization should be introduced to the benefits of Geospatial technologies. And all IT projects from inception to completion should explore using Geospatial technology capabilities.

5.5 Contributors

The quality of the Interior-wide guidance provided within this TRM chapter is a reflection of the efforts of the Geospatial technologies Domain team. The members of the team are:

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