OpenGIS Consortium Discussion Paper 01-037

"Location Organizer Folder Draft Candidate Implementation Specification 1.03"

This paper presents a discussion of technology issues considered in a Special Interest Group of the Open GIS Consortium Technical Committee. The content of this paper is presented to create discussion in the geospatial information industry on this topic; the content of this paper is not to be considered an adopted specification of any kind. This paper does not represent the official position of the Open GIS Consortium nor of the OGC Technical Committee.

TITLE: Location Organizer Folder Specification

OGC DOCUMENT: OGC- 01-037

VERSION 1.03

DATE: *30 March, 2001*

TYPE: OGC-IP Draft Candidate Implementation Specification, Discussion Paper

This version:
http://feature.opengis.org/members/archive/arch01/01-037.pdf

Previous versions:
http://ip.opengis.org/gfspp/docs/LofSpecificationV1.03.doc
http://ip.opengis.org/gfspp/docs/LofSpecificationV.3.doc

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Abstract

The Location Organizer Folder (LOF) is a GML document that provides a structure for organizing the information related to a particular event or events of interest. It may be used in various analysis applications, like disaster analysis, Intelligence analysis, etc. It is spatially enabled, and capable of managing disparate types of information.

The LOF is an information structure. There may be a variety of services external to the LOF that provide the means for generation and manipulation of the information in the structure. This includes search and discovery, parsing different resources and extracting useful information, assigning spatial attributes, relating (linking) resources of interest, and so on.

This document was created as a part of the OGC Geospatial Fusion Services Testbed (GFST 2000) and Geospatial Fusion Services Pilot Project (GFSPP 2001). Even though the LOF is meant to be a generic structure, it is not completely independent from the services that process it, which were also built during these projects. Thus, the document describes the structure of the LOF, and to some extent, the system and some of the services that process the LOF. In the future, the LOF will become a completely generic information structure, decoupled from any specific component that can use it.

Section 1 describes the framework in which the LOF will be used. It is a description of a system that might use the LOF. It is based on the system built during the OGC GFST and GFSPP projects. Section 2 presents the model of the LOF. Section 3 discusses the use of links and relationships in the LOF.

Status of this document

This document is a draft candidate implementation specification. It represents "work in progress" and should be treated accordingly.

Editorial Comments

ED: [Editorial Notes are inserted in RED, wherever needed.]

Issues

All issues, and applicable resolutions, are documented inline. Please use the format below as a guideline for documenting issues.

> **Issue Name**: [Issue Name in RED, BLUE, or GREEN based upon criticality of the issue, with Red being highest priority. (Initials, Date)]
> **Issue Description:** [Issue Description.]
> **Resolution:** [Insert Resolution Details and History. (your name , date)]

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1. LOF Framework

This section describes the function of a generic "LOF system", the role of the LOF and other components in the system, relationship between the LOF and other components, and manipulations by services and applications on the LOF. The description is based on the system built during the OGC GFST and GFSPP projects, so it does involve some specifics, but we will concentrate on the generic aspects of the system, i.e. functionality that any system that operates with the LOF might implement.

1.1 Functions of a containing system

The functionality of the system that operates with the LOF is:

1. Discover and extract the information that is useful for a particular analysis that is performed.
2. Extract useful information from free text resources like cables, text messages etc.
3. Correlate resources organized in the LOF. This is one of the most important functions of the system. LOF therefore must provide the means to create and describe relations between resources.
4. Browse resources and information stored in LOF.
5. Perform analysis on the collected set of information represented in the LOF.
6. Present the information. There should be means for visual presentation of geo-spatial features overlaid on a map, and also presentation of other types of resources, using associated specific applications.
7. Manipulate the LOF(s): Filter the LOF, perform union or intersection of LOFs, and copy the LOF.
8. Share and exchange LOFs among users.

For a detailed description of functionality of a system like this, refer to the GFST Use Cases document of the Geospatial Fusion Services Testbed Project.

1.2 Containing system architecture

The example system architecture of which the LOF can be a part of is presented in the Figure 1.

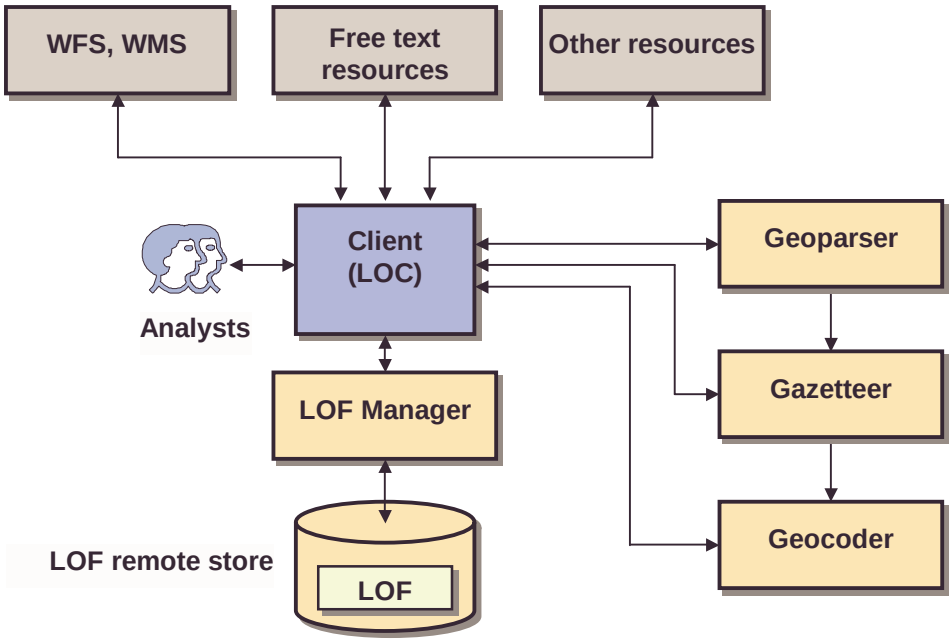


Figure 1. A containing system architecture

One of the main functions of a system like this is to extract the information from various resources and to assign that information various specific attributes. In this architecture, the Geoparser/Gazetteer/Geocoder (3G) services are examples that perform such an operation. In general, these are network accessible components.

Geoparser parses the free text (news, messages, reports, etc.) and marks up recognized terms and phrases of interest. Recognition is performed against preset vocabularies, possibly specified by the user at runtime. Output of the Geoparser is the collection of features that identifies words and phrases in the original text resource.

Gazetteer is the service that retrieves known geometry for features that have well-known feature identifiers, like landmarks. A feature identifier is a well-known name or description such as that which is output from the Geoparser Service.

Geocoder is the service that performs the transformation of the location description of a feature into a normalized location description that includes the geometry of the feature.

3G services may be accessed by the client separately, but may also be chained, so that the client provides the input to the chain (free text resource to the Geoparser), and receives the feature collection with spatial (geometry) attributes as output from the Geocoder.

LOF Manager is the mediator (on the LOF side) between the LOF and services and applications that work on the information stored in the LOF. It is usually implementation dependant. For example, its implementation depends on the type of data store that is used for storing the LOF.

The Client handles the presentation of the Location Organizer Folder to the operator, and allows the operator access to services for manipulating resources associated with the LOF.

WFS (OGC Web Feature Server), WMS (OGC Web Map Server), free text resources and other resources are, in general, Web accessible repositories and servers that provide information that might be of interest to the LOF user (analyst of the event of interest).

2. LOF Model

2.1 Object model

Location Organizer Folder is a generic information structure that can be used in a variety of applications. It is a stateless Feature Collection defined on an Area Of Interest (AOI). As previoulsy mentioned, there are some basic actions that will always be performed on it, but we also might imagine others -- application specific ones. In this sense, we define a “core”, or “basic” LOF model, and assume that it can be extended. The general object model of the LOF is presented in Figure 2.

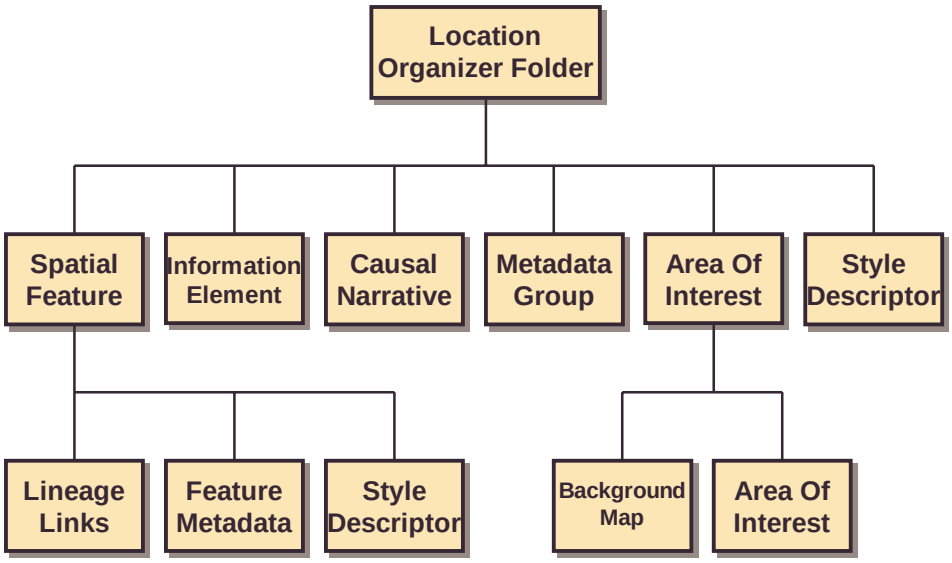


Figure 2. General object model of the LOF

A detailed object model of the LOF, created from the LOF schema (Appendix A) in the schema editor, is presented in Figure 3.

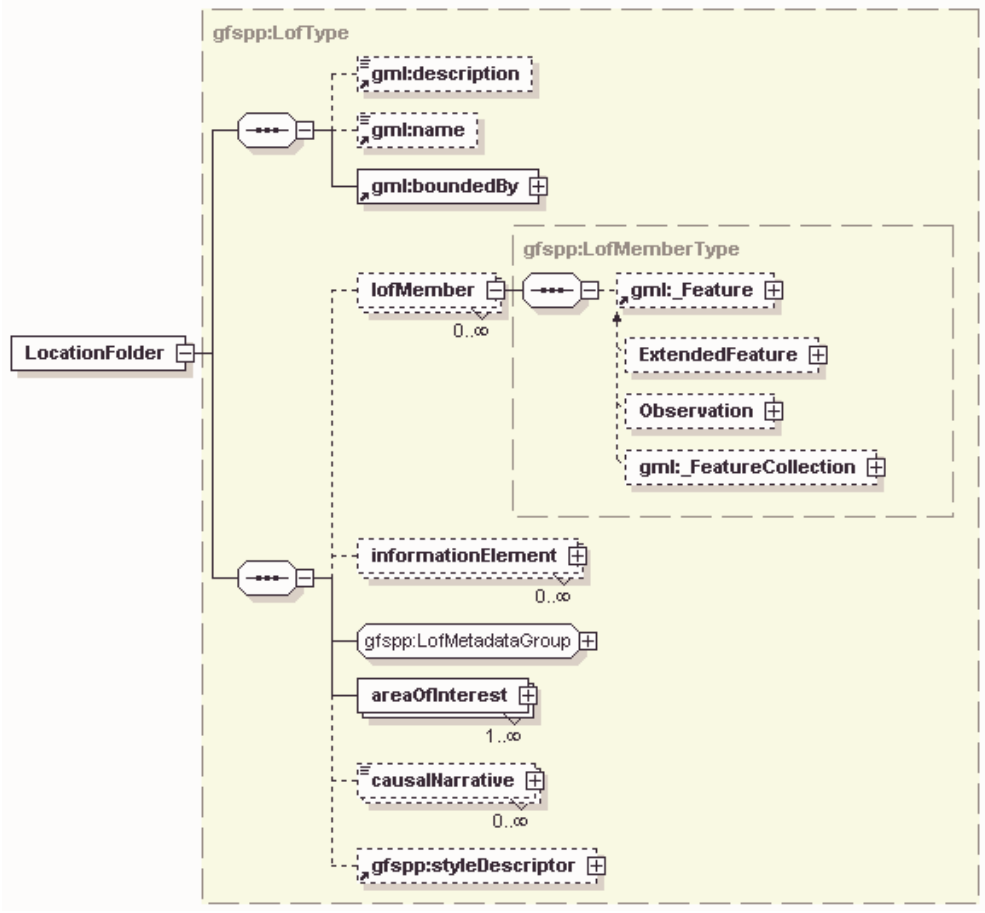


Figure 3. Detailed object model of the LOF

Spatial Feature

The Spatial Feature in the LOF is based on the GML feature, as defined in GML 2.0. It may or may not have geometry. LOF can contain any number of LOF features. The type of the LOF feature derives from the basic GML feature type by adding properties specific to the LOF (links, metadata and style). It is expected that the basic LOF feature type will be further extended to facilitate any application-specific need. Applications will probably define some concrete specific feature types, for example, geography ones: Road, Park, etc. Actually, in the LOF schema, as presented in this document, two concrete feature types are defined based on the basic LOF feature type – ExtendedFeatureType and ObservationType. Extended Feature serves as a container for exchanging the data between the LOF and 3G services, and Observation feature is a feature specific to event analysis. For detailed descriptions of these two types, see sections 2.2 Feature type hierarchy and 2.4 3G Services.

LOF feature can be local to the LOF or remote. In that sense LOF conforms to GML 2.0 specification. It can also contain links to other features or other types of resources, local or remote. Section 3. Geolinks in the Location Organizer Folder describes the linking mechanisms in the LOF.

LOF is a feature collection, which is in turn, by the definition from GML, is also a feature. Therefore, a feature in the LOF may reference another LOF.

Detailed models of the AbstractLofFeatureType, ExtendedFeatureType and Observation type are presented in Figures 4, 5 and 6.

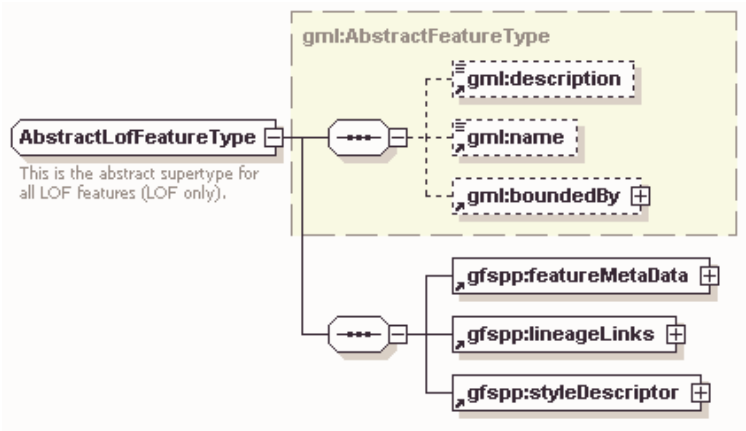


Figure 4. AbstractLofFeatureType Model

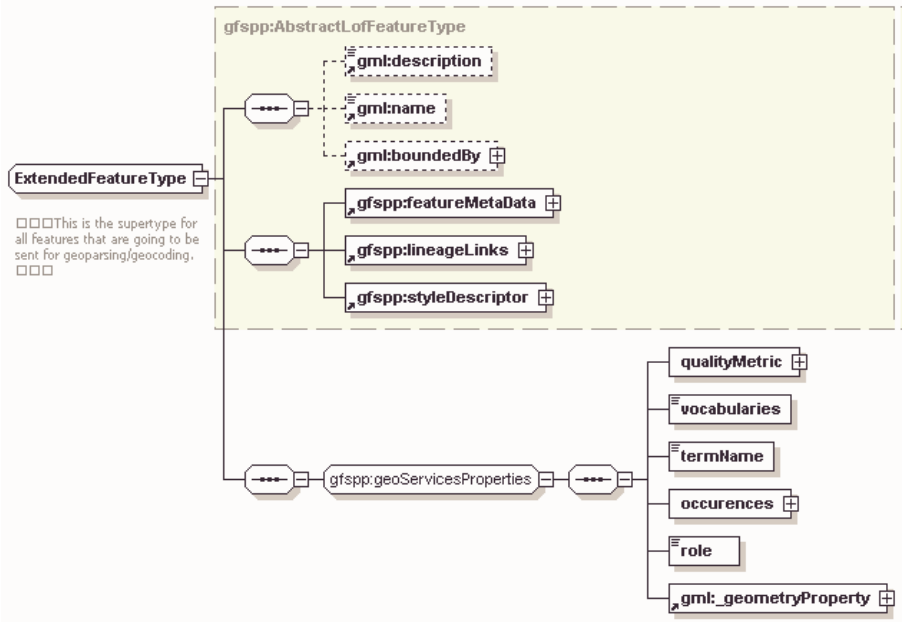


Figure 5. ExtendedFeatureType Model

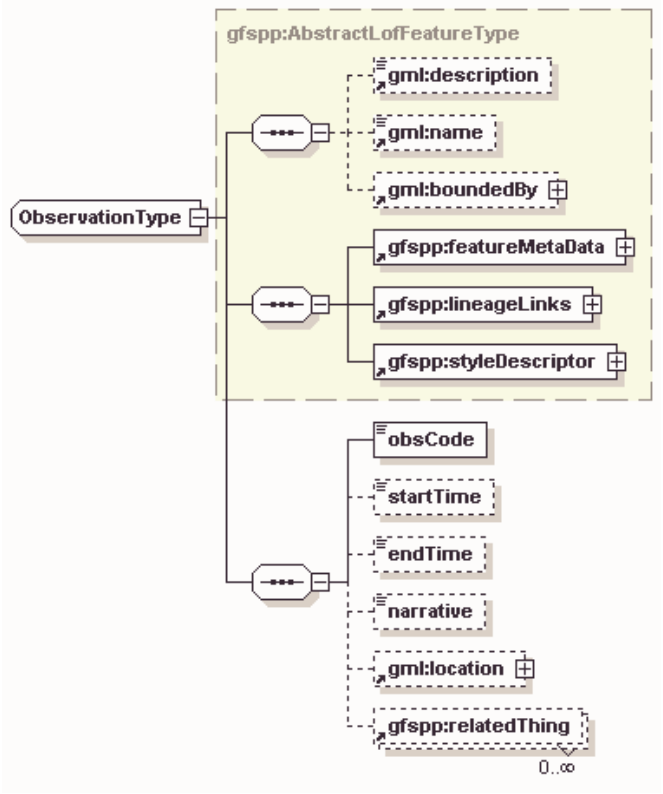


Figure 6. ObservationType Model

Lineage Link

Lineage Links element tracks the creation history of the feature. It holds the information of the sources from which the feature is created. There are two properties in LineageLinks: *sourceFeature* and *baseFeature*. The *sourceFeature* references the feature from which the feature was created (for example by copying). The *baseFeature* references the resource from which the feature was created in the first place. This use of LineageLinks is shown in the example case in the Figure 7.

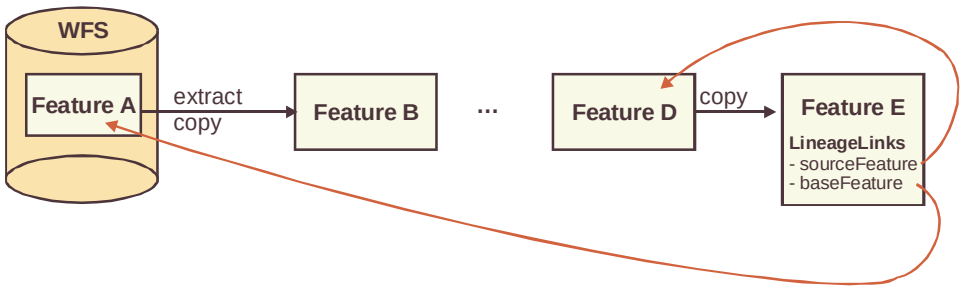


Figure 7. Function of Lineage Links

Feature Metadata

Feature metadata is a Property Group element that contains metadata specific to the LOF feature. There are specific semantics for the Property Group construct. It holds the properties that are in fact properties of the parent element (in this case a feature) rather than itself. Specific properties of a LOF feature include:

- creator
- date of creation
- source
- security
- label.

Security is a string that describes the security level on the feature. It might be redefined in the future to allow for a more fine grained security description.

Style Descriptor

The Style Descriptor element declares the default style for a feature or LOF. It ensures that, while the styling and the content of the data is strongly separated, there is a means to persist the styling for a particular feature, or for the whole LOF. The analyst will be able to save and later use not only the data that he has added to the LOF but also it's presentation. Of course, the style descriptor holds only the default style which can be overriden by user actions.

Syle descriptor contains two pieces of information about the style. *defaultStyle* is an URI reference to the style that is used on this feature/LOF. s*tyleType* denotes the type of the style referenced by the defaultStyle. Based on the value of the styleType property, a client is able to perform proper styling. At the moment, the type of the styleType property is string, but it might be an enumeration of known styling types (using Extensible Stylesheet Language, Styled Layer Descriptor and so on…)

Information Element

Information elements are typically non-spatial entities including voice records, cables, e-mail messages, and the like. However, they may be any network resources that are referenced from geo-spatial features in the LOF. As mentioned earlier, this is the primary function of the client, or the containing system in general - to create and maintain relationships in the LOF, including relationships between feature elements and Information Elements. The process of "geo-referencing an

Information Element" relates the Information Element to a geo-spatial feature. In many cases, this will require that a geo-spatial feature be created. In fact the only way to associate an Information Element with a geo-spatial feature, and hence to provide it with a location, is to make the Information Element the value of a property of a geo-spatial feature.

Information elements may also contain links to resources local to LOF, or remote ones.

A *GeoText message* is a "cable" or some other form of text resource. It is "free-text" message, which means that no constraints are put on it. It may also be marked-up text. GeoText message is one of the main sources from which information of interest is extracted and stored in the LOF. 3G services perform the operations of extracting, geocoding (assigning spatial attributes) and creating LOF features. LOF features created in this way contain links back to the words and phrases in the GeoText message from which they were created. For a detailed description of GeoText message parsing, refer to the 2.4 3G Services section.

VoiceRecord, *SignalRecord* and *Image* are "multimedia" objects. A VoiceRecord is an object that contains the digitized record of a conversation or conversations. A SignalRecord is an object that contains the digitized record of an electronic signal associated with some form of communication. An Image is an object that contains the digitized record of a visual image as might be acquired by a frame or scanning camera from a terrestrial, space borne or aerial platform. They all may or may not be geo-referenced. If they are geo-referenced, it is assumed they are related to some existing geo-spatial feature. As such, these information element objects may be defined as the values of properties of geo-spatial features.

Figure 8 presents a model of the informationElementPropertyType whose value can be one of mentioned InformationElement types.

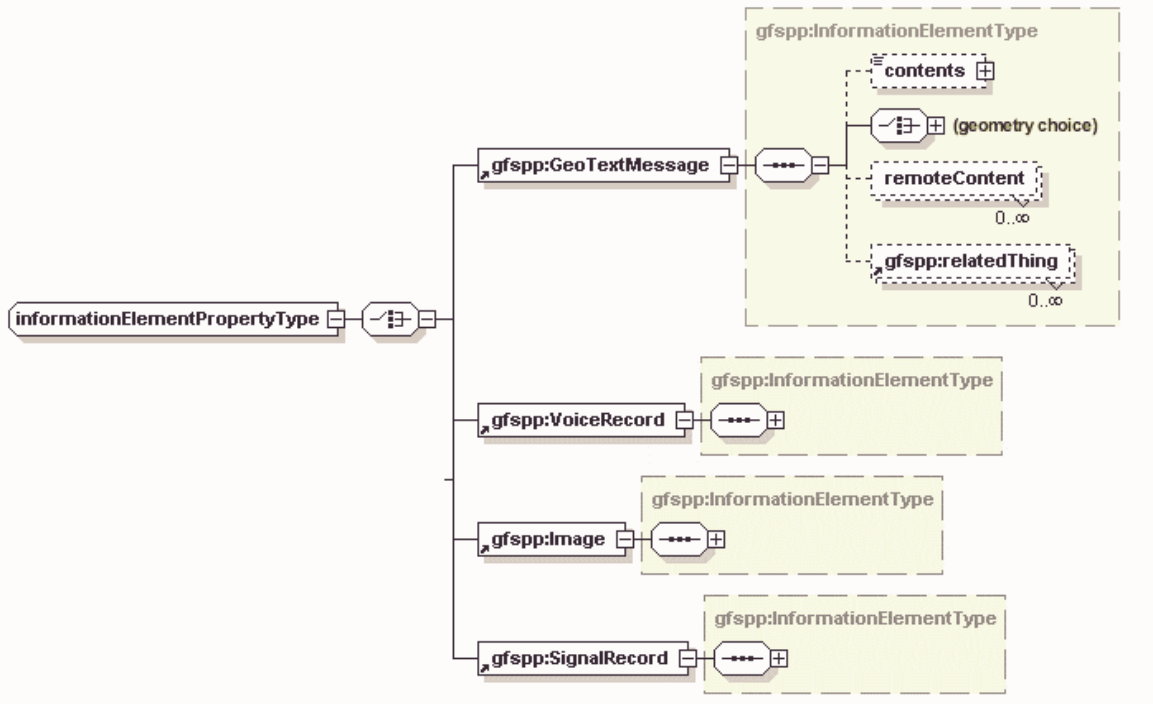


Figure 8. Information Element Types

Causal Narrative

LOF optionally contains a causal narrative. A causal narrative is human readable text-based explanation of the incident described by the LOF. This is created by the analyst in the course of assembling the LOF and is the analyst's integration or fusion of the events and activities that the LOF references.

The Causal Narrative is composed of segments, each of them representing one CausalNarrative element in the LOF. Each segment has an identified author or authors. Segments can be replaced or updated. There is no requirement to maintain an audit trail of changes to these segments, in this release.

The Causal Narrative can incorporate XLinks (simple, bare name Xpointers) from arbitrary text fragments to other elements of the LOF, namely to geo-spatial features or information elements. Links from the Causal Narrative cannot point outside of the LOF.

The function of the Causal Narrative element is shown in the Figure 9.

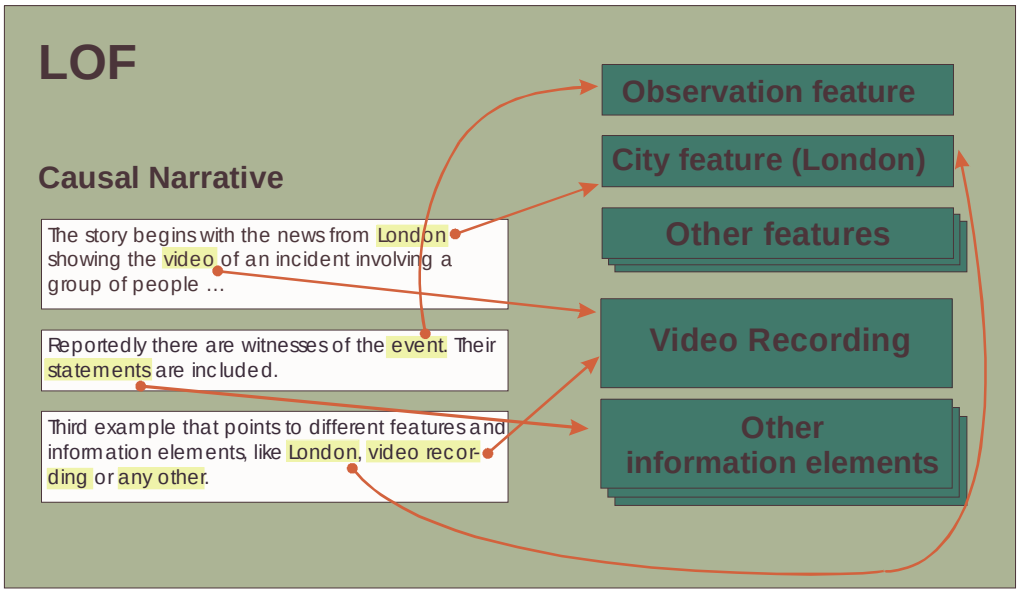


Figure 9. Causal Narrative

Metadata Group

This group holds the metadata that describes the LOF. Rather than using Property Group element like in the case of feature metadata, LOF metadata group is XML Schema group, which means that every property element group is a direct child of the LOF. The group contains the following metadata properties:

- *creator, organization, creationDate* – the creator of the LOF, the organization that owns the LOF and the date of LOF creation.
- *security* – security level for the LOF. It is at the moment a string, but it might be defined to be more complex in the future to allow for richer description of LOF security.
- *ProblemSetType* - identifies the type of problem set. The type is an internal name or code established by the user organization.
- *referenceVocabulary* - the reference to the Reference Vocabulary for the LOF. This vocabulary defines the key terms and concepts that pertain to the problem set (these are pre-built and exist in the vocabulary "pool" available to all users).
- *lofVocabulary* - the reference to the LOF Vocabulary. Initially, this defaults to the Reference Vocabulary, but has additional terms/concepts that get added through the course of LOF manipulation activities.
- *latestRevisionDate and latestAccessDate* – latest update/access dates.

Area Of Interest and Backgroud Map

LOF has number of Area of Interest elements. Area of Interest (AOI) defines the spatial extent of a region of the Earth's surface. It defines a real world area that is of interest for a particular analysis, and to which resources in the LOF are related. There is only one primary AOI. There may be a number of sub-AOIs. They are organized in a hierarchical structure.

The model for the AOI-Background Map hierarchy is shown in the Figure 10.

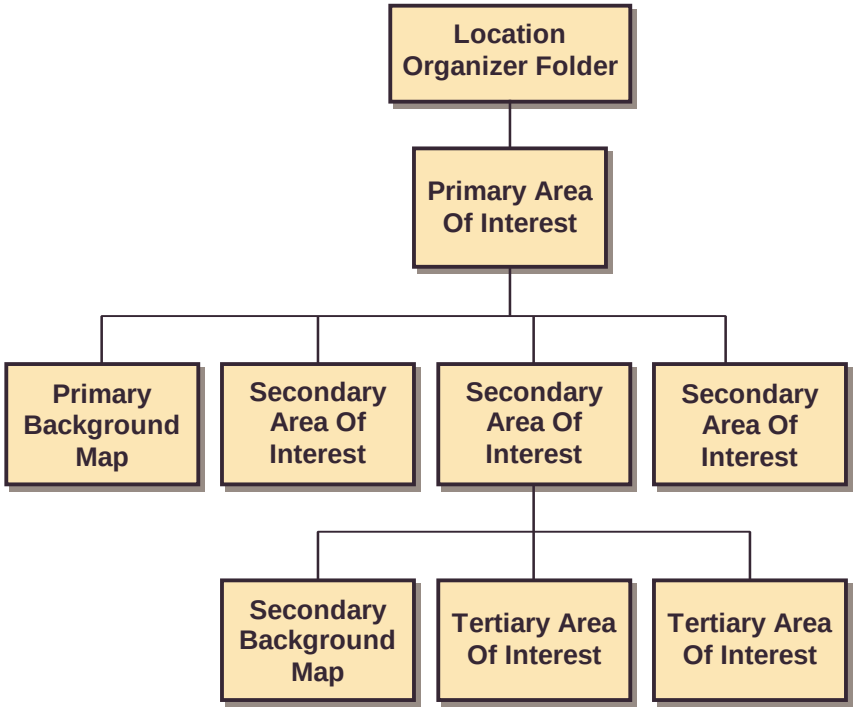


Figure 10. Area of Interest and Background Map Hierarchy

Every AOI has an associated Background Map element that covers the extent defined by the AOI. Actually, the spatial extent of the AOI might be different from the spatial extent of it's associated background map, since it might happen that an analyst wants to use the map that covers only a part of the AOI's extent. Typically the background map is an image map (GIF, PNG etc.), but this is not a requirement. It is anticipated that the background map will be obtained using a WMS interface from an OGC Web Map Server, although this is not a requirement.

Areas of Interest can be visualized as polygon elements overlaid on the surface of the background map, at the same hierarchy level. Users will typically create an area

of interest by loading a background map and drawing or otherwise defining the area of interest. The Primary AOI may be defined relative to a map of the earth.

2.2 Feature type hierarchy

As mentioned earlier, LOF feature is based on the GML feature as defined in the GML 2.0. Base LOF feature type is defined as abstract. It is extended in the client application according to user requirements.

The hierarchy of the feature type definition in the LOF is presented in Figure 11.

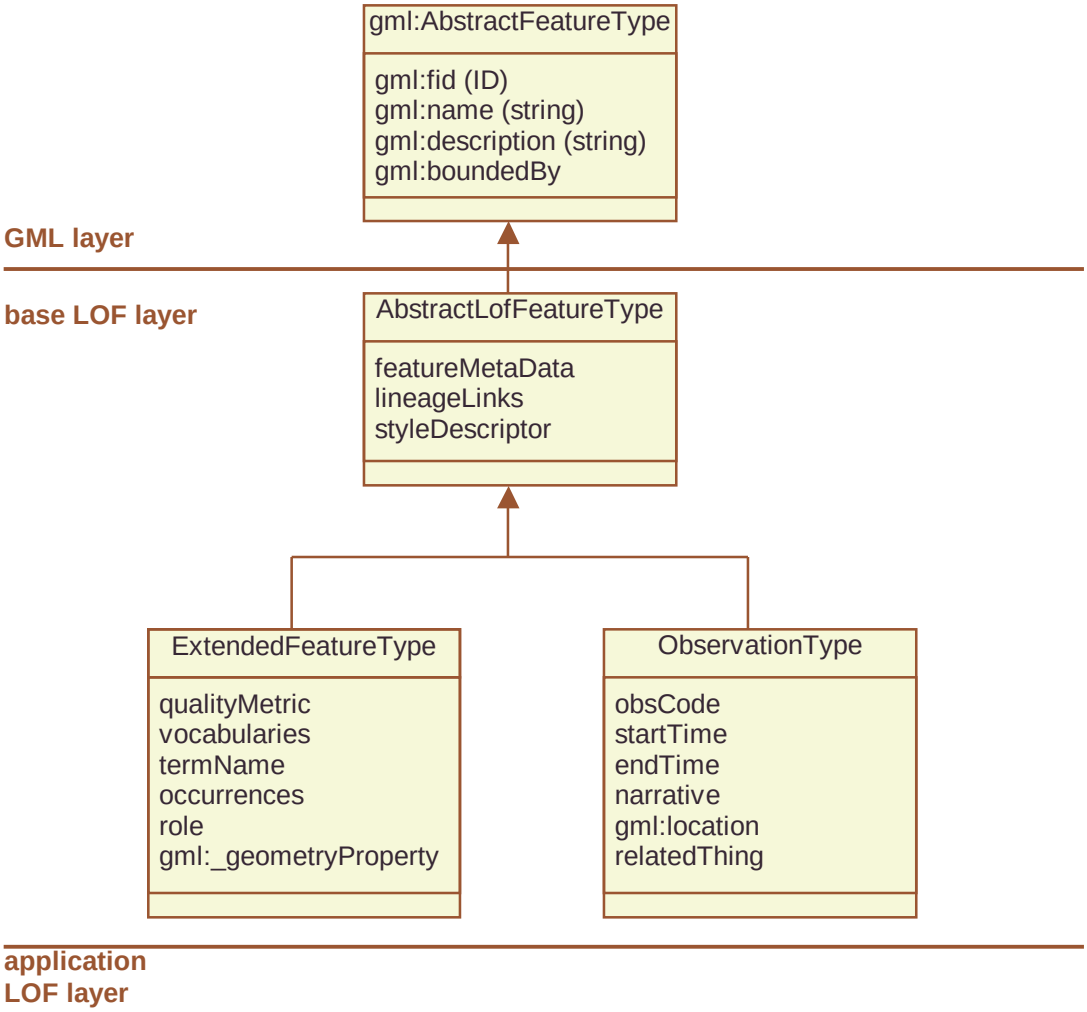


Figure 11. Feature Type Hierarchy

We have identified three schema layers. Basic layer is the GML layer which defines basic types that will be used to define application schemas (feature, geometry, etc.).

So from the GML point of view, both base LOF layer and application LOF layer are applications of GML. However, we use the same principle in defining the LOF. There are some basic types that will be used in all LOF applications and we therefore define the base LOF layer (schema). Anything that is application specific is an application of the base LOF.

We have already described the base LOF feature, i.e. AbstractLofFeatureType and it's properties. It is further extended at the level of the base LOF schema to create two concrete feature types.

The *ExtendedFeatureType* defines the feature that is used in the processing of the information by the 3G services. The processing starts with a text message from which well-known terms and phrases are extracted, and features with spatial attributes are created. Those features contain links back to original words and phrases in the GeoText message. Instances of the ExtendedFeatureType are used to store intermediate results of the processing of the Geoparsing/Geocoding service chain, including:

- links back to the text source
- a list of vocabularies used
- references to one or more recognized terms (e.g., London in the UK, and London in Canada)
- references to terms found in source text documents
- geometry associated with terms

For more detailed description of ExtendedFeatureType and processing performed by the 3G services, see section 2.4 3G Services.

The ObservationType is a concrete feature type that represents an observation of a *person, place, organization, equipment* or *event*. It extends the definition of the base LOF feature (AbstractLofFeatureType) as described below:

- *obsCode* is the property that defines the type of the observation. It is an enumerated type of the following values: Person, Organization, Event, Equipment and Location.
- *startTime* and *endTime* define the duration of the observation.
- *narrative* property is a human readable description of the observation.
- *gml*:*location* is spatial (geometry) property of the observation, i.e. the location where the observation took place.
- *relatedThing* is a Remote Property (Simple Xlink) type property. It points to any resource, local or remote that is related to the observation. Any given ObservationType instance may have zero or more *relatedThing* properties.

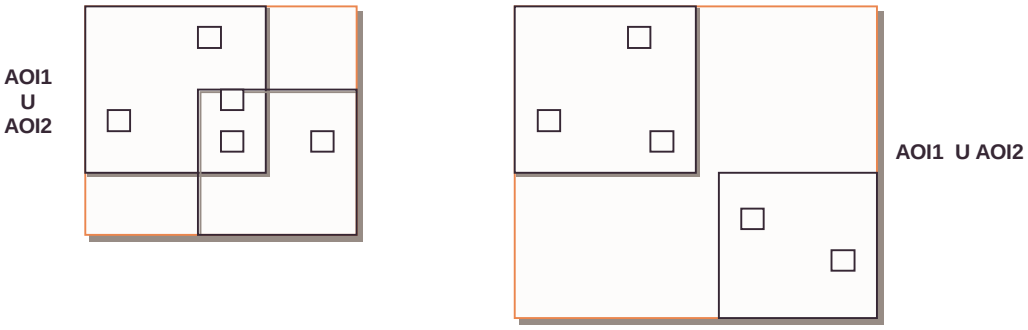
2.3 Union and intersection of LOFs

A LOF is a spatially enabled information structure, and it is also a collection of features. Spatial extent of a LOF is defined by it's primary AOI. So let's first define union and intersection of two AOIs.

AOI is defined as a Box geometry (square shape). It can have any number of children AOIs. The union of two AOIs is a Box (spatial extent) of which both of AOIs are a part and which contains all of the children of the two AOIs. The union of two AOIs is shown in Figure 12.

Figure 12. Union of two AOIs

Intersection of two AOIs is defined as the spatial extent that is part of both AOIs, and contains all of children AOIs that are not completely out of it's boundaries. It is shown in the Figure 13.



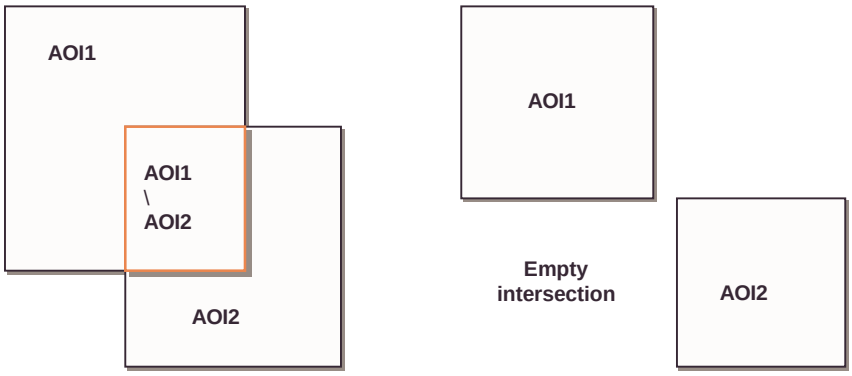


Figure 13. Intersection of two AOIs

Having defined the union and intersection of AOIs, we can now define the union/intersection of two LOFs.

Th union of two LOFs is the union of their primary AOIs, and contains all the features and information elements from both LOFs.

The intersection of two LOFs is the intersection of their primary AOIs and contains all features and information elements that are not completely out of it's boundaries. If a feature is not spatially enabled, it belongs to the new LOF.

Issue Name: [Temporal Union and Intersection. (HAN, 3/28/01)]
Issue Description: [Likewise, there remains the question of what happens in temporal space, as a result of union or intersection operations.]
Resolution: [Open. (name , date)]

2.4 3G Services

The 3G Services are Geoparser, Geocoder and Gazetteer. When chained together, they can be used to process free-text resources to create geo-spatial features.

The input to the Geoparser is a free-text resource, such as a "cable" or other type of message stored in a GeoText message. The Geoparser outputs the collection of recognized words and phrases with the information about the recognition process. This includes the vocabularies used, the estimated quality of the recognition and links back to the input text source.

The output of the Geoparser may serve as input to a Geocoder or Gazetteer service. The Geocoder and Gazetteer services update ExtendedFeatureType instances with spatial attributes. ExtendedFeatureType is a concrete feature type that is used as a container for the result of this processing. Having the ExtendedFeatureType instance, it is easy to insert the result of the 3G processing into a LOF without any modifications or mapping between the feature that is created by the 3G services and the LOF feature.

Also, there is important metadata about the processing that took place that is stored with the ExtendedFeatureType instance as described below:

- *qualityMetric* – describes the quality of the performed service. Recognizes that a term in free-text is rarely guaranteed to be 100% accurate. Therefore, the service provides it's estimate of how accurate the recognition was.
- *vocabularies* – the recognition is performed against some vocabulary. The term might appear in different vocabularies, for example, the term "London" might appear in both "UK Place Names" and "Canadian Place Names"

vocabularies. It also might have different meanings in different vocabularies, for example Washington might be the place name as well as a person's name. Therefore with every recognized term, there is the reference to the used vocabulary.

- *termName* - The word or phrase that is marked recognized.
- *occurrences* – This is the list of occurrences in the source text. Every *occurrence* element consists of the pointer (Simple Xlink) to the original text document, and two non-negative integers representing ordinals of the first and last characters of the term in the source document.
- *role* – describes the meaning of the found term.
- *gml:_geometryProperty* – geometry property associated with the feature by the gazetteer/geocoder.

3. Geolinks in the Location Organizer Folder

Geolinks are the means for referencing resources, local or remote, from resources in the LOF (or GML in general). Geolinks are based on the Xlinks specification, as defined in GML 2.0. For the purpose of GML, the Geolinks specification only groups Xlink attributes to allow for using two basic geolink entities: remote properties (Xlink Simple Link) and relationships (Xlink Extended Link). The Geolinks specification is at the moment not completely part of the GML. However, GML does declare Xlink attributes necessary for forming Geolink constructs. But the definition of the remote properties or relationships is not the part of GML, and it needs to be included in an application schema, such as the LOF schema.

3.1 Remote properties

Remote properties are Xlink Simple Link constructs. They allow for uni-directional linking, with the containing resource representing the start of the link, and the target resource representing the end of the link. In the LOF, RemotePropertyType is defined and used for definition of remote property elements. The following properties are defined as Remote Properties in the LOF:

- *lofMember* property. It is based on lofMember property from GML and it inherits the RemoteProperty behavior. It is used to reference features that are stored remotely, outside the LOF document. It might also be used to reference other LOFs, since LOF is also a feature.
- *relatedThing* property. It is a member of ObservationType and InformationElementType. It can be used to reference any resource that is related to a particular feature or information element instance.
- *sourceFeature and baseFeature* properties.
- *remoteContent* property of the InformationElement.
- *backgroundMap* property.

3.2 Relationships (extended Xlinks) in LOF

Relationships are not the part of the LOF schema at this time. Only simple links (remote properties) are used. However, there is the need to define links that are more complex than a remote property. The main purpose of the LOF and systems that use it is that it provides a means for forming and exploiting related collections of geo-connected resources, as applications warrant. Analysts are interested in the semantics (meaning, value) of the resources in a LOF, and that semantics is built by

defining LOF feature/information element relationships with other feature/information elements, and with other Web resources.

Remote properties are simple properties that have a URI reference to a remote resource and some metadata in the form of its attributes that describe the role of the property.

Relationships are objects (in contrast to properties) that have their own properties and provide rich descriptions of a relationship. A relationship allows for linking more than two resources, bi-directional traversing, the complete separation of resources and the relationship amongst them, and so on.

The object model of the Relationship object is shown in the Figure 14.

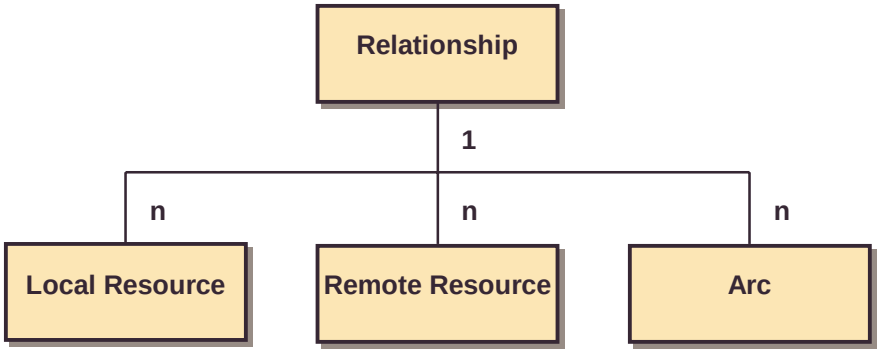


Figure 14. Relationship Object Model

Relationship is a full-fledged object that represents the whole relationship. It has three types properties – Local Resource, Remote Resource and the Arc. It can contain any number of those properties.

Local Resource is a property that contains a local resource. The meaning of the word "local" is that the resource is inlined in the Local resource property.

Remote Resource is a property that contains a reference to a remote resource. "Remote" means only that the resource is not inlined in the property. It can exist in the local document at different places in the hierarchy, or somewhere outside the document. Remote Resource is similar to the Remote Property of Simple Xlinks.

Arc is a property that contains the description of the actual link between two of the resources specified in the relationship. For each pair of resources specified in the relationship object, one Arc property might exist.

References

For the latest version of any OGC specification, please consult the list of OpenGIS Specifications available at http://www.opengis.org.

Normative References

1. **Geography Markup Language 2.0**, OGC Recommendation (20 February 2001), available online at: <http://www.opengis.net/gml/01-029/GML2.html>
2. **Web Feature Server Specification.** OGC Draft Candidate Implementation Specification, available online: <http://feature.opengis.org/members/archive/arch01/01-023r1.pdf>
3. **Gazetteer Service Specification.** OGC Draft Candidate Implementation Specification, available online: <http://feature.opengis.org/members/archive/arch01/01-036.pdf>
4. **Geoparser Service Specification.** OGC Draft Candidate Implementation Specification, available online: <http://feature.opengis.org/members/archive/arch01/01-035.pdf>
5. **Geocoder Service Specification.** OGC Draft Candidate Implementation Specification, available online: <http://feature.opengis.org/members/archive/arch01/01-026r1.pdf>
6. **W3C Candidate Recommendation for XML Schema (24 October 2000),** available online: <http://www.w3.org/TR/2000/CR-xmlschema-0-20001024/>
7. **GFST Use Cases**, available online at: <http://coverage.opengis.org/ip2000/docs/GFSTUseCases_V1.2.doc>
8. **Web Map Server Specification.** OGC Draft Candidate Implementation Specification, available online: <http://feature.opengis.org/members/archive/arch01/01-021r1.pdf

Glossary

Term	Definition

Appendix A: The Location Organizer Folder Schema, v1.03 (Normative)

Listing 1: lof.xsd v1.03

```
<?xml version="1.0" encoding="UTF-8"?>

<!-- GFSPP LOF -->

<schema targetNamespace="http://www.opengis.net/namespaces/gfspp"
xmlns:geoparser="http://www.opengis.net/namespaces/geoparser"
xmlns:gfspp="http://www.opengis.net/namespaces/gfspp"
xmlns="http://www.w3.org/2000/10/XMLSchema" xmlns:gml="http://www.opengis.net/gml"
xmlns:xlink="http://www.w3.org/1999/xlink" elementFormDefault="qualified">
    <annotation>
        <appinfo>lof.xsd v1.03 2001-02</appinfo>
        <documentation>
            Base LOF schema for GFSPP demo scenario, Copyright (c) 2001 OGC, All Rights Reserved.
            Version: 1.03
            Previous version: 1.02
            Changes from previous version: Defined obsCode as an enumeration type
        </documentation>
    </annotation>
    <!-- ============================================================
    import and include
    ============================================================ -->
    <!--
    <import namespace="http://www.opengis.net/gml"
schemaLocation="http://www.opengis.net/namespaces/gml/core/feature.xsd"/>
    <import namespace="http://www.opengis.net/namespaces/geoparser"
schemaLocation="http://www.opengis.net/namespaces/geoparser/Vocabulary.xsd"/>
    -->
    <import namespace="http://www.opengis.net/gml" schemaLocation="../../gml/2.05/feature.xsd"/>
    <import namespace="http://www.opengis.net/namespaces/geoparser"
schemaLocation="../../3g/0.7/Vocabulary.xsd"/>
    <!-- ============================================================
    root element
    ============================================================ -->
    <element name="LocationFolder" type="gfspp:LofType"/>
    <!-- ============================================================
    abstract elements
    ============================================================ -->
    <!-- a label for restricting membership in a LOF collection, if desired -->
    <element name="_AbstractLofFeature" type="gfspp:AbstractLofFeatureType" abstract="true"/>
    <!-- ============================================================
    pre-defined LOF features
    ============================================================ -->
    <element name="Observation" type="gfspp:ObservationType" substitutionGroup="gml:_Feature"/>
    <element name="ExtendedFeature" type="gfspp:ExtendedFeatureType"
substitutionGroup="gml:_Feature"/>
    <!-- ============================================================
    information elements
    ============================================================ -->
    <element name="GeoTextMessage" type="gfspp:InformationElementType"/>
    <element name="VoiceRecord" type="gfspp:InformationElementType"/>
    <element name="Image" type="gfspp:InformationElementType"/>
    <element name="SignalRecord" type="gfspp:InformationElementType"/>
    <!-- ============================================================
```

```
    metaData element
    ========================================================== -->
    <element name="featureMetaData" type="gfspp:FeatureMetaDataType"/>
    <!-- ==========================================================
    some remote properties (others can be definde in the same manner)
    ========================================================== -->
    <element name="relatedThing" type="gfspp:RelatedThingType"/>
    <!-- ==========================================================
    lineageLinks element
    ========================================================== -->
    <element name="lineageLinks" type="gfspp:LineageLinksType"/>
    <!-- ==========================================================
    styleDefault element
    ========================================================== -->
    <element name="styleDescriptor" type="gfspp:StyleDescriptorType"/>
    <!-- ==========================================================
    LOF type
    ========================================================== -->
    <complexType name="LofType">
        <complexContent>
            <extension base="gml:AbstractFeatureCollectionBaseType">
                <sequence>
                    <element name="lofMember" type="gfspp:LofMemberType" minOccurs="0"
maxOccurs="unbounded"/>
                    <element name="informationElement" type="gfspp:informationElementPropertyType"
minOccurs="0" maxOccurs="unbounded"/>
                    <group ref="gfspp:LofMetadataGroup"/>
                    <element name="areaOfInterest" type="gfspp:areaOfInterestType"
maxOccurs="unbounded"/>
                    <element name="causalNarrative" type="gfspp:causalNarrativeType" minOccurs="0"
maxOccurs="unbounded"/>
                    <element ref="gfspp:styleDescriptor" minOccurs="0"/>
                </sequence>
            </extension>
        </complexContent>
    </complexType>
    <group name="LofMetadataGroup">
        <sequence>
            <element name="creator" type="string"/>
            <element name="organization" type="string"/>
            <element name="creationDate" type="date"/>
            <element name="security" type="string"/>
            <element name="problemSetType" type="uriReference"/>
            <element name="referenceVocabulary" type="uriReference"/>
            <element name="lofVocabulary" type="geoparser:VocabularyType"/>
            <element name="latestRevisionDate" type="date"/>
            <element name="latestAccessDate" type="date"/>
        </sequence>
    </group>
    <!-- ==========================================================
    LOF member type
    ========================================================== -->
    <complexType name="LofMemberType">
        <annotation>
            <documentation>
            A lofMember will accept any feature (or feature collection)
            </documentation>
        </annotation>
        <complexContent>
            <restriction base="gml:FeatureAssociationType">
                <sequence>
                    <element ref="gml:_Feature" minOccurs="0"/>
                </sequence>
            </restriction>
        </complexContent>
```

```
    </complexType>
    <!-- ========================================================
    base, abstract LOF feature type
    ======================================================== -->
    <complexType name="AbstractLofFeatureType" abstract="true">
        <annotation>
            <documentation>This is the abstract supertype for all LOF features (LOF
only).</documentation>
        </annotation>
        <complexContent>
            <extension base="gml:AbstractFeatureType">
                <sequence>
                    <element ref="gfspp:featureMetaData"/>
                    <element ref="gfspp:lineageLinks"/>
                    <element ref="gfspp:styleDescriptor"/>
                </sequence>
            </extension>
        </complexContent>
    </complexType>
    <!-- ========================================================
    base Extended LOF feature type (used as input to the geoparser/gazeteer/geocoder) services
    ======================================================== -->
    <complexType name="ExtendedFeatureType">
        <annotation>
            <documentation>
            This is the supertype for all features that are going to be sent for geoparsing/geocoding.
            </documentation>
            <appinfo>Extended Feature</appinfo>
        </annotation>
        <complexContent>
            <extension base="gfspp:AbstractLofFeatureType">
                <sequence>
                    <group ref="gfspp:geoServicesProperties"/>
                </sequence>
            </extension>
        </complexContent>
    </complexType>
    <group name="geoServicesProperties">
        <sequence>
            <element name="qualityMetric" type="gfspp:QualityMetricType"/>
            <element name="vocabularies" type="string"/>
            <element name="termName" type="string"/>
            <element name="occurences" type="gfspp:OccurencesType"/>
            <element name="role" type="string"/>
            <element ref="gml:_geometryProperty"/>
        </sequence>
    </group>
    <complexType name="QualityMetricType">
        <sequence>
            <element name="accuracy" type="gfspp:AccuracyType" minOccurs="0"/>
            <element name="note" type="gfspp:NoteType" minOccurs="0"/>
        </sequence>
    </complexType>
    <simpleType name="AccuracyType">
        <restriction base="string"/>
    </simpleType>
    <simpleType name="NoteType">
        <restriction base="string"/>
    </simpleType>
    <complexType name="OccurencesType">
        <sequence>
            <element name="occurence" maxOccurs="unbounded">
                <complexType>
                    <sequence>
                        <element name="Range">
```

```
                        <complexType>
                            <attribute ref="xlink:href" use="optional"/>
                            <attribute name="start" type="nonNegativeInteger" use="required"/>
                            <attribute name="end" type="positiveInteger" use="required"/>
                        </complexType>
                    </element>
                    <element name="QoS" type="nonNegativeInteger"/>
                </sequence>
                <attribute name="id" type="string"/>
            </complexType>
        </element>
    </sequence>
</complexType>
<!-- ========================================================
define some common LOF Intel feature types
========================================================= -->
<complexType name="ObservationType">
    <annotation>
        <documentation/>
        <appinfo>Observation Feature</appinfo>
    </annotation>
    <complexContent>
        <extension base="gfspp:AbstractLofFeatureType">
            <sequence>
                <element name="obsCode" type="gfspp:ObsCodeType"/>
                <element name="startTime" type="gfspp:StartTimeType" minOccurs="0"/>
                <element name="endTime" type="gfspp:EndTimeType" minOccurs="0"/>
                <element name="narrative" type="gfspp:NarrativeType" minOccurs="0"/>
                <element ref="gml:location" minOccurs="0"/>
                <element ref="gfspp:relatedThing" minOccurs="0" maxOccurs="unbounded"/>
            </sequence>
        </extension>
    </complexContent>
</complexType>
<simpleType name="ObsCodeType">
    <annotation>
        <documentation/>
        <appinfo>Observation Code</appinfo>
    </annotation>
    <restriction base="string">
        <enumeration value="Person"/>
        <enumeration value="Organization"/>
        <enumeration value="Equipment"/>
        <enumeration value="Location"/>
        <enumeration value="Event"/>
    </restriction>
</simpleType>
<simpleType name="StartTimeType">
    <annotation>
        <documentation/>
        <appinfo>Start Time</appinfo>
    </annotation>
    <restriction base="string"/>
</simpleType>
<simpleType name="EndTimeType">
    <annotation>
        <documentation/>
        <appinfo>End Time</appinfo>
    </annotation>
    <restriction base="string"/>
</simpleType>
<simpleType name="NarrativeType">
    <annotation>
        <documentation/>
        <appinfo>Narrative</appinfo>
```

```
            </annotation>
            <restriction base="string"/>
        </simpleType>
        <!-- ================================================================
        LOF feature metadata element group
        ================================================================ -->
        <complexType name="FeatureMetaDataType">
            <sequence>
                <annotation>
                    <documentation/>
                    <appinfo>Feature Metadata</appinfo>
                </annotation>
                <element name="Creator" type="gfspp:CreatorType"/>
                <element name="CreationDate" type="gfspp:CreationDateType"/>
                <element name="Source" type="gfspp:SourceType"/>
                <element name="Security" type="gfspp:SecurityType"/>
                <element name="label" type="gfspp:LabelType"/>
                <!-- Security should probably be of enumeration or even some complex type, but for the start
it's a string -->
            </sequence>
        </complexType>
        <simpleType name="CreatorType">
            <annotation>
                <documentation/>
                <appinfo>Creator Type</appinfo>
            </annotation>
            <restriction base="string"/>
        </simpleType>
        <simpleType name="CreationDateType">
            <annotation>
                <documentation/>
                <appinfo>Creation Date Type</appinfo>
            </annotation>
            <restriction base="string"/>
        </simpleType>
        <simpleType name="SourceType">
            <annotation>
                <documentation/>
                <appinfo>Source Type</appinfo>
            </annotation>
            <restriction base="string"/>
        </simpleType>
        <simpleType name="SecurityType">
            <annotation>
                <documentation/>
                <appinfo>Security Type</appinfo>
            </annotation>
            <restriction base="string"/>
        </simpleType>
        <simpleType name="LabelType">
            <annotation>
                <documentation/>
                <appinfo>Label Type</appinfo>
            </annotation>
            <restriction base="string"/>
        </simpleType>
        <!-- ================================================================
        Lineage links to ancestors of a feature
        ================================================================ -->
        <complexType name="LineageLinksType">
            <sequence>
                <annotation>
                    <documentation/>
                    <appinfo>Lineage Links</appinfo>
                </annotation>
```

```
            <element name="sourceFeature" type="gfspp:SourceFeatureType"/>
            <element name="baseFeature" type="gfspp:BaseFeatureType"/>
        </sequence>
    </complexType>
    <complexType name="SourceFeatureType">
        <annotation>
            <documentation/>
            <appinfo>Source Feature</appinfo>
        </annotation>
        <complexContent>
            <extension base="gfspp:RemotePropertyType"/>
        </complexContent>
    </complexType>
    <complexType name="BaseFeatureType">
        <annotation>
            <documentation/>
            <appinfo>Base  Feature</appinfo>
        </annotation>
        <complexContent>
            <extension base="gfspp:RemotePropertyType"/>
        </complexContent>
    </complexType>
    <!--==================================================================
    Style descriptor
    =================================================================== -->
    <complexType name="StyleDescriptorType">
        <sequence>
            <annotation>
                <documentation/>
                <appinfo>Style Descriptor</appinfo>
            </annotation>
            <element name="defaultStyle" type="gfspp:DefaultStyleType"/>
            <element name="styleType" type="gfspp:StyleTypeType"/>
        </sequence>
    </complexType>
    <simpleType name="DefaultStyleType">
        <annotation>
            <documentation/>
            <appinfo>Default Style</appinfo>
        </annotation>
        <restriction base="uriReference"/>
    </simpleType>
    <simpleType name="StyleTypeType">
        <annotation>
            <documentation/>
            <appinfo>Style Type</appinfo>
        </annotation>
        <restriction base="string"/>
    </simpleType>
    <!-- ==================================================================
    information element property type
    =================================================================== -->
    <complexType name="informationElementPropertyType">
        <choice>
            <element ref="gfspp:GeoTextMessage"/>
            <element ref="gfspp:VoiceRecord"/>
            <element ref="gfspp:Image"/>
            <element ref="gfspp:SignalRecord"/>
        </choice>
    </complexType>
    <!-- ==================================================================
    information element type
    =================================================================== -->
    <complexType name="InformationElementType">
        <sequence>
```

```
            <element name="contents" minOccurs="0">
                <complexType mixed="true">
                    <sequence>
                        <any namespace="##any" processContents="skip"/>
                    </sequence>
                </complexType>
            </element>
            <choice>
                <element ref="gml:pointProperty" minOccurs="0"/>
                <element ref="gml:polygonProperty" minOccurs="0"/>
                <element ref="gml:lineStringProperty" minOccurs="0"/>
                <element ref="gml:multiPointProperty" minOccurs="0"/>
                <element ref="gml:multiLineStringProperty" minOccurs="0"/>
                <element ref="gml:multiPolygonProperty" minOccurs="0"/>
            </choice>
            <element name="remoteContent" type="gfspp:RemotePropertyType" minOccurs="0"
maxOccurs="unbounded"/>
            <element ref="gfspp:relatedThing" minOccurs="0" maxOccurs="unbounded"/>
        </sequence>
        <attribute name="fid" type="ID"/>
    </complexType>
    <!-- ================================================================
    causal narrative type
    ================================================================ -->
    <complexType name="causalNarrativeType" mixed="true">
        <sequence>
            <element name="pointer" type="gfspp:pointerType" minOccurs="0"
maxOccurs="unbounded"/>
        </sequence>
        <attribute name="ordinal" type="positiveInteger" use="required"/>
        <attribute name="author" type="string"/>
        <attribute name="date" type="string"/>
    </complexType>
    <complexType name="pointerType">
        <simpleContent>
            <extension base="string">
                <attribute ref="xlink:href" use="required"/>
            </extension>
        </simpleContent>
    </complexType>
    <!-- ================================================================
    area of interest type
    ================================================================ -->
    <complexType name="areaOfInterestType">
        <sequence>
            <element ref="gml:description" minOccurs="0"/>
            <element ref="gml:name" minOccurs="0"/>
            <element ref="gml:Box"/>
            <element name="backgroundMap" type="gfspp:backgroundMapType"/>
            <element name="areaOfInterest" type="gfspp:areaOfInterestType" minOccurs="0"
maxOccurs="unbounded"/>
        </sequence>
    </complexType>
    <!-- ================================================================
    background map type
    ================================================================ -->
    <complexType name="backgroundMapType">
        <complexContent>
            <extension base="gfspp:RemotePropertyType">
                <sequence>
                    <element ref="gml:Box"/>
                </sequence>
            </extension>
        </complexContent>
    </complexType>
```

```
    <!-- ====================================================================
    A thin wrapper around Simple Link from xlink
    ==================================================================== -->
    <complexType name="RelatedThingType">
        <annotation>
            <documentation/>
            <appinfo>Link to a related resource</appinfo>
        </annotation>
        <complexContent>
            <extension base="gfspp:RemotePropertyType"/>
        </complexContent>
    </complexType>
    <!-- ====================================================================
    A thin wrapper around Simple Link from xlink
    ==================================================================== -->
    <complexType name="RemotePropertyType">
        <attributeGroup ref="xlink:simpleLink"/>
        <attribute ref="gml:remoteSchema" use="optional"/>
    </complexType>
</schema>
```

Appendix B: Revision history

Version 1.03

- Defined ExtendedFeatureType and ObservationFeatureType
- Reduced the definition of geolinks to remote properties (Simple Xlinks)
- Changed the LOF schema to be compliant with the latest GML (2.0) and XML Schema (October 2000) specifications
- Updated the version number to be consistent with the schema version number

Appendix C: Future considerations

This appendix lists items that we might consider for future development of the LOF. This document was built during the OGC GFST and GFSPP projects and one of the results of those projects is the list of "lessons learned" we summarize below.

- LOF should be made independent of the services that process it.
- LOF needs the notion of State and a State History. At the moment, the Causal Narrative element captures very simple history information over the time (narrative), but the State and State History would have the effect of partitioning the LOF and dividing all of its elements into chunks by State.
- Introduce the relationships, as described in the section 3. Geolinks in Location Organizer Folder.
- Minor structural cleaning. For example, feature metadata properties are members of a PropertyGroup element named FeatureMetadata, while LOF metadata elements are members of the LOF, directly. However, there is no semantical difference between them, so we could use the same technique.

Issue Name: [Need for examples. (JVD, 3/28/01)]
Issue Description: [The LOF spec doesn't have any examples! It really should show/include examples conveying XML instances of basic LOF elements such as 'areaOfInterest', 'informationElement', 'causalNarrative', 'informationElement' and 'lofMember' (features and geolinks) elements (i.e., show real-world fragments of LOF "instance documents".]
Resolution: [Open. (name , date)]