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Web 3D Service

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i. Preface

NOTE The previous version of this document was numbered 04-096, now renumbered 05-019 after approval and final editing in 2005.

Although this specification defines a stand-alone web service for the 3D visualization of geographic data, the document refers strongly to other OGC specifications. It is based on the ISO/DIS 19128 Web Map Service standard, the OGC's OWS Common Implementation Specification (V0.3.0) and the Web Terrain Service (V0.5.0). The document structure is adopted from other OGC Implementation Specifications.

ii. Submitting organizations

The following organizations submitted this Implementation Specification to the Open Geospatial Consortium Inc.

SIG 3D of the GDI-NRW

(Special Interest Group of the Geodata Infrastructure of North-Rhine Westphalia, GERMANY).

Find more at: http://www.gdi-nrw.de

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v. Revision history

Date	Release	Author	Primary clauses modified	Description
2003-10-25	0.1.0	Thomas H. Kolbe		First internal SIG 3D version
2004-07-03	0.2.0	Thomas H. Kolbe		Mapping coordinate axes from real world to computer graphics GetScene: BBOX becomes mandatory GetScene: scene's displacement to local coordinates GetScene: new parameters TRANSFORM, ENVIRONMENT, MINHEIGHT, MAXHEIGHT
2004-12-15	0.3.0	Udo Quadt		Complete restructuring of the document using OGC template English translation

vi. Changes to the OGC Abstract Specification

The OGC™ Abstract Specification does not require changes to accommodate the technical contents of this document.

vii. Future work

NOTE Generalization of the service interface now specified in this Discussion Paper has not yet been considered by the OGC. Such generalization of this interface will include considering combining the functions supported here with functions currently supported by other OGC (approved and draft) web services.

This specification was developed in the context of the Pilot 3D of the initiative geodata infrastructure North Rhine-Westphalia (GDI-NRW). The pilot 3D concerns the interoperable visualization of 3D city- and regional models. Different prototypical implementations of the W3DS have been realized and are still running. Further improvements are desirable to support:

a) **Queryable W3DS**
Like the GetFeatureInfo operation of a WMS, a W3DS should return the information about an interactively selected object in the scene graph. The returned information about selected objects will be formatted as an XML file (e.g., GML 3) for automatic computation or it could be displayed right into the 3D scene graph.

b) **Environmental enhancements of the scene**
For a more realistic display of the scene graph, it would be desirable to define additional sources of light (street lights, the moon, etc.) or adding atmospheric conditions like fog or rain.

c) **Generating animations and predetermined flight of camera**
Instead of interactive navigation through the 3D scene, sometimes it may be desired to get an automatic sequence or movie of the 3D models. Predefined routes through cities and buildings could be used as demos for trade fairs etc.

d) **Adding additional output formats**
It should be considered if the W3DS could be applied as a basis for an open, interoperable 3D streaming service. It should be checked if other output formats beside the recommended ones (VRML97, GeoVRML and X3D) are feasible.

e) **Styled LayerDescriptors**
The concept of Styled Layer Descriptors is described in the Styled Layer Descriptor

Implementation Specification. It enables the user to control the graphical style of 3D graphic elements.

f) **Build on OWS Common**
This document should more extensively build on the OGC Web Services Common Specification (OGC 05-008), normatively referencing parts of that document instead of repeating information.

Foreword

This version of the specification cancels and replaces all previous versions.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. Open Geospatial Consortium Inc. shall not be held responsible for identifying any or all such patent rights. However, to date, no such rights have been claimed or identified.

Introduction

The Web 3D Service is a portrayal service for three-dimensional geodata, delivering graphical elements from a given geographical area. In contrast to the OGC Web Mapping service (WMS) and the OGC Web terrain service (WTS) 3D scene graphs are produced. These scene graphs will be rendered by the client and can interactively be explored by the user. The W3DS merges different types (layers) of 3D data in one scene graph. (cf. Figure 1).

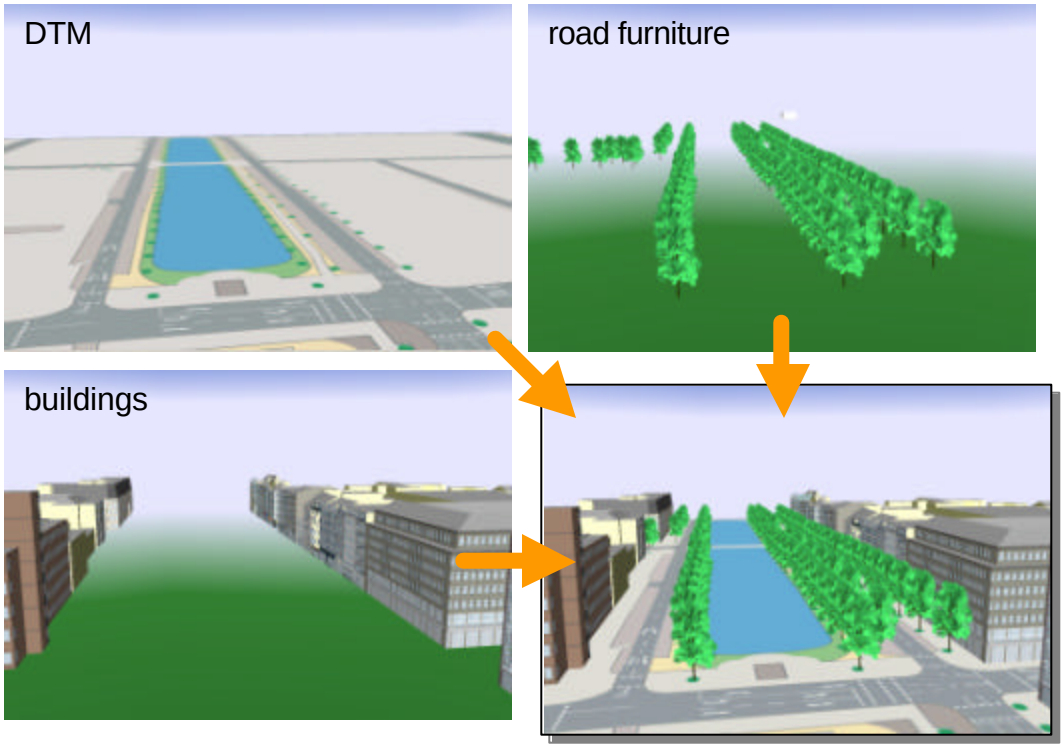

Figure 1 — Different types of geodata are merged in one 3D scene graph

3D scene graphs represent visual illustrations of 3D geodata and are not the geodata themselves. They do not contain the semantic characteristics and relations of the basic geodata. For gaining access to the 3D geodata OGC's Web Feature Service is recommended. All implementations of a Web 3D Service shall support VRML97 as default output format. Still other formats like GeoVRML or X3D are strongly advised compensating disadvantages of the aged VRML97 standard.

Geo-visualization using web services (taken from [4])

Concerning the portrayal of spatial data the OpenGIS Consortium employs a four level visualization pipeline, which describes visualization as a multi-level process starting from non-graphical object representations stored in a repository (e.g. a database) and ending with the final presentation of graphical entities on a display device (see Doyle and Cuthbert 1998 [1]). The lowest level is built by the spatial data resources. In a selection step the interesting

objects are retrieved. The second step transforms the selected spatial objects to a graphical representation, i.e. the spatial objects are mapped to display elements. In the third step the generated display elements are rendered to an image, which in the final step is displayed to the user by an appropriate output device (cf. Figure 2).

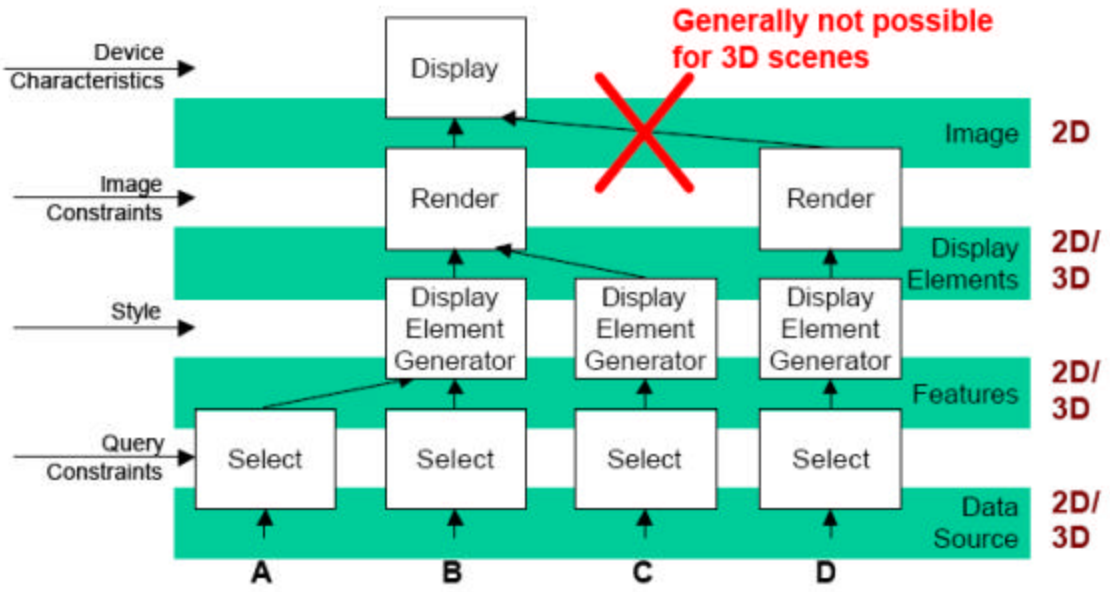

Figure 2 — The component structure of the portrayal pipeline allows the integration of data on different levels in order to obtain an integrated visualization (Doyle & Cuthbert 1998 [1]). Besides on the image level objects can have both two or three dimensional geometries

As can be seen from Figure 2 the merging of data from different sources can take place at different levels of the visualization pipeline. After the selection of the spatial objects to be presented the data from path A are merged into path B, where for the objects from both A and B display elements are generated. Further display elements from path C are integrated before an image containing all graphic elements from A, B, and C is rendered. At the time of presentation another image can be integrated from path D as an overlay to the previously generated image. The latter approach is often used for the stacking of (2d) web map layers delivered from distributed web map services. The advantage is that the services that are to be combined only have to be compatible on the level of map graphics (JPG, TIFF or PNG in most cases), but not on the levels below. This allows the integration of maps from different systems that otherwise has nothing else in common.

Unfortunately, 3D visualizations cannot be integrated on the image level, since rendered images are only 2d. If two systems render views of the same scene, these images may not simply be overlaid, because the lower image can show objects that are nearer to the camera as the objects in the upper image. Nearer objects then might be covered by the rendered objects in the upper image. Therefore, 3D integration has to take place earlier, i.e. on the level of display elements. For proper integration of different sets of display elements then it is necessary that they have 3D geometries and use the same spatial reference system.

The components of the portrayal pipeline have not to reside on the same system; they can be distributed over the internet. However, in client-server applications the lower level components are typically realized by one or more servers while the remaining visualization tasks are handled by the client. According to their complexity clients are classified into thick, medium, and thin clients (cf. Figure 2). Thick clients communicate on the feature level with the server. The advantage is that the client is free to realize any – including very complex – visualization and interaction schemes. The major drawback wrt. to web applications is the need of a special web browser plug-in which implements these schemes. The plug-in has to be downloaded and installed by users before they can start with the visualization and interaction. Medium clients also need a plug-in for 3D visualization. However, if the display elements are represented using international standards like VRML, X3D or SVG, existing standard plugins can be used. The advantage of medium clients is that 3D plug-ins typically provide functionalities for real time rendering and navigation and therefore allow a high degree of interaction. Thin clients only have to cope with rendered images. Thus the most important advantage of thin clients wrt. to thick and medium clients is that they do not need any plug-in and can be used by standard web browsers on practically every computer system. However, since images are static, possibilities for interaction and navigation in the presented 3D scene are strongly limited.

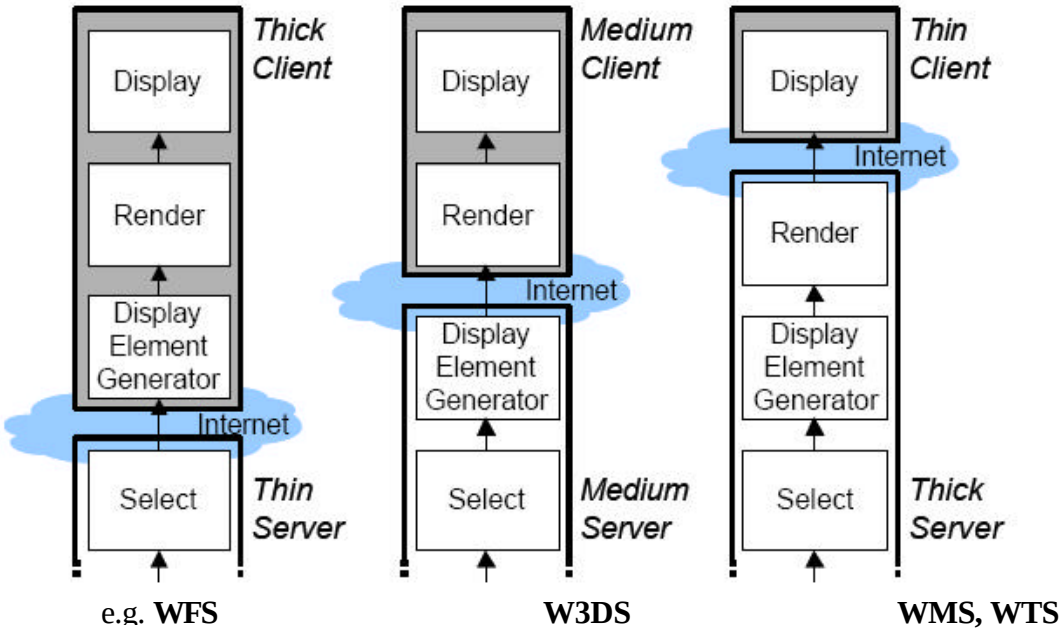

Figure 3 — Different balancing schemes between client and server

The decision which client model is appropriate for what application depends on the specific application scenario on the one hand and the availability of appropriate data and services on the other hand. If 3D visualization plays only a minor role, for example, when a 3D view of a sports arena has to be shown in an online ticket service application, a thin client should be used. If the application focus is instead on interactive exploration, at least a medium client has

to be used. A typical thin client displays bitmaps of a WMS or WTS and thick client is needed for the complex data handling of a WFS. By focusing on medium clients, the W3DS fills the gap between thin and thick servers (cf. Figure 3). The use of standard formats and standard plug-ins allows the widespread and easy use of data visualisation including interaction by the user.

Historical Background

The idea of the W3DS was developed in the context of the initiative geodata infrastructure North Rhine-Westphalia (GDI-NRW), resulting in a prototype named Pilot 3D. The Pilot 3D implements the interoperable geo-visualization of 3d city and regional models. Several W3DS implementations are already running and experiences made during the test phase are reflected in this draft specification.

Web 3D Service

1 Scope

This is a proposal for a specification of a web service which delivers a 3D scene graph. This is an aggregation of 3D graphical elements, which can be explored interactively by a user.

2 Conformance

Conformance with this draft specification shall be checked using all the relevant tests specified in Annex A (normative) of the ISO/DIS 19128 Web Map Service standard.

3 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this document:

EPSG, *European Petroleum Survey Group Geodesy Parameter*s, Lott, R., Ravanas, B., Cain, J., Girbig, J.-P., and Nicolai, R., eds., http://www.epsg.org/

IETF RFC 2045 (November 1996), *Multipurpose Internet Mail Extensions (MIME) PartOne: Format of Internet Message Bodie*s, Freed, N. and Borenstein N., eds., http://www.ietf.org/rfc/rfc2045.txt

IETF RFC 2616 (June 1999), *Hypertext Transfer Protocol – HTTP/1.1*, Gettys, J., Mogul, J., Frystyk, H., Masinter, L., Leach, P., and Berners-Lee, T., eds., http://www.ietf.org/rfc/rfc2616.txt

IETF RFC 2396 (August 1998), *Uniform Resource Identifiers (URI): Generic Syntax*, Berners-Lee, T., Fielding, N., and Masinter, L., eds., http://www.ietf.org/rfc/rfc2396.txt

ISO 8601:1988(E), *Data elements and interchange formats - Information interchange - Representation of dates and time*s.

ISO/DIS 19128 (2004), *Web Map Service, Version 1.3.0*, Jeff de La Beaujardiere, http://portal.opengis.org/files/?artifact_id=5316

ISO/IEC 14772-1:1997 (1997), *The Virtual Reality Modeling Language (VRML97)*, http://www.web3D.org/technicalinfo/specifications/vrml97/vrml97specification.pdf

ISO/IEC FDIS 19775:200x (2004): Information technology — Computer graphics and image processing — Extensible 3D (X3D). http://www.web3d.org/x3d/specifications/ISO-IEC-19775-IS-X3DAbstractSpecification/

OGC AS 12 (September 2001), *The OpenGIS Abstract Specification Topic 12: OpenGIS Service Architecture (Version 4.2*), Kottman, C. (ed.), http://www.opengis.org/techno/specs.htm

OGC (2004): *OWS Common Implementation Specification, Version 0.3.0.* Arliss Whiteside. http://portal.opengis.org/files/?artifact_id=6324

OGC (2002), *Styled Layer Descriptor Implementation Specification, Version: 1.0.0*, William Lalonde, OGC 02-070, https://portal.opengeospatial.org/files/?artifact_id=1188

WTS 0.5.0 (November 2003) OGC 03-081r2, Web Terrain Service Implementation Specification, v0.5.0, Lieberman, J., Sonnet, J., http://www.opengis.org/docs/03-081r2.pdf

XML 1.0 (October 2000), *Extensible Markup Language (XML) 1.0 (2nd edition*), World Wide Web Consortium Recommendation, Bray, T., Paoli, J., Sperberg-McQueen, C.M., and Maler, E., eds., http://www.w3.org/TR/2000/REC-xml

4 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

4.1
client
software component that can invoke an operation from a server

4.2
coordinate reference system
coordinate system that is related to the real world by a datum [ISO 19111]

4.3
coordinate system
set of mathematical rules for specifying how coordinates are to be assigned to points [ISO 19111]

4.4
geographic information
information concerning phenomena implicitly or explicitly associated with a location relative to the Earth [ISO 19101]

4.5
interface
named set of operations that characterize the behaviour of an entity [ISO 19119]

4.6
layer
basic unit of geographic information that may be requested as a map from a server

4.7
map
portrayal of geographic information as a digital image file suitable for display on a computer screen

4.8
operation
specification of a transformation or query that an object may be called to execute [ISO 19119]

4.9
portrayal
presentation of information to humans [ISO 19117]

5 Conventions

5.1 Symbols (and abbreviated terms)

This document uses the following abbreviated terms.

DTD	Document Type Definition
EPSG	European Petroleum Survey Group
GDI	Geodata infrastructure
GeoVRML	VRML with a extension for 3D geodata
GML	Geography Markup Language
HTTP	Hypertext Transfer Protocol
IETF	Internet Engineering Task Force
MIME	Multipurpose Internet Mail Extensions
NRW	North-Rhine Westphalia
OGC	Open Geospatial Consortium
POC	Point Of Camera
POI	Point Of Interest
RFC	Request for Comments
SIG	Special Interest Group
SLD	Styled Layer Descriptor
SRS	Spatial Reference System
URL	Uniform Resource Locator

UTC	Universal Time Coordinated
VRML	Virtual Reality Modeling Language
WCS	Web Coverage Service
WFS	Web Feature Service
WMS	Web Mapping Service
WTS	Web Terrain Service
XML	Extensible Markup Language

6 Basic service elements

6.1 Introduction

This clause specifies aspects of Web 3D Server behaviour that are independent of particular operations or are common to several operations. If not further noted the service's behaviour is in accordance with the ISO/DIS 19128 Web Map Service standard and OGC's OWS.

6.2 Version numbering and negotiation

6.2.1 Version number form and value

The Web 3D Service defines a protocol version number. The version number applies to the XML schema and the request encodings defined in this draft specification. The version number contains three nonnegative integers, separated by decimal points, in the form "x.y.z". The numbers "y" and "z" shall not exceed 99.

Implementations of this draft specification shall use the value "0.1.0" or "0.3.0" as the protocol version number.

6.2.2 Version number changes

The protocol version number shall be changed with each revision of this draft specification. The number shall increase monotonically and shall comprise no more than three integers separated by decimal points, with the first integer being the most significant. There may be gaps in the numerical sequence. Some numbers may denote draft versions. Servers and their clients need not support all defined versions, but shall obey the negotiation rules below.

6.2.3. Appearance in requests and in service metadata

The version number appears in at least two places: in the service metadata, and in the parameter list of client requests to a server. The version number used in a client's request of a particular server shall be equal to a version number which that instance has declared it supports (except during negotiation as described below). A server may support several versions, whose values clients may discover according to the negotiation rules.

6.2.4. Version number negotiation

A W3DS client may negotiate with a server to determine a mutually agreeable protocol version. Negotiation is performed using the GetCapabilities operation (described in 7.2) according to the rules described in the ISO/DIS 19128 Web Map Service standard and OGC's OWS specification.

The VERSION parameter is mandatory in requests other than GetCapabilities.

6.3 General HTTP request rules

HTTP request rules are identically treated as in the ISO/DIS 19128 Web Map Service standard.

6.4 General HTTP response rules

HTTP responese rules are identically treated as in the ISO/DIS 19128 Web Map Service standard.

6.5 Output formats

At present the only mandatory output format MIME type is model/vrml for GetScene and text/xml for the GetCapabilities request.

6.6 Request parameter rules

Request parameter rules are identically treated as in the ISO/DIS 19128 Web Map Service standard.

6.7 Cascading and chaining W3DS

The principles of cascading and chaining a web services are valid for the W3DS, too. Description is given at the OWS and WMS specification. The W3DS is suitable in particular for the integrated visualization of adjacent city models (mosaic scenario) or into one another interlocked models (hierarchy scenario).

6.8 Exceptions

At a service exception an error document will be returned to the client. The output format of the error report depends on the value of the EXCEPTION parameter (clause 7.3.2.19).

7 Web 3D service operations

7.1 Introduction

The two operations defined for a Web 3D Service are GetCapabilities and GetScene. This Clause specifies the implementation and use of these W3DS operations in the Hypertext Transfer Protocol (HTTP) Distributed Computing Platform (DCP).

7.2 GetCapabilities (mandatory)

7.2.1 General

The purpose of the mandatory GetCapabilities operation is to obtain service metadata, which is a machine readable (and human-readable) description of the server's information content and acceptable request parameter values.

The GetCapabilities operation is mandatory for all OGC web service and is extensively described in the OWS Common Implementation Specification and the ISO/DIS 19128 Web Map Service standard. For reasons of more comfortable reading, the main points will be repeated and will be adapted for the W3DS when necessary.

7.2.2 GetCapabilities request overview

The general form of a W3DS request is defined in clause 6. When making the GetCapabilities request of a W3DS server, which may offer other service types as well, it is necessary to indicate that the client seeks information about the Web 3D Service in particular. Thus, the SERVICE parameter of the request shall have the value "W3DS" as shown in clause 6.

Table 1 — The parameters of the GetCapabilities request URL

Name and example	Mandatory/ Optional	Description
VERSION=version	O	Request version
SERVICE=W3DS	M	Service type
REQUEST=GetCapabilities	M	Request name
FORMAT=MIME_type	O	Output format of service metadata
UPDATESEQUENCE=string	O	Sequence number of string for cache control

Example URL:

```
http://myserver.de/W3DS?SERVICE=W3DS&REQUEST=GetCapabilities
```

7.2.3 Request parameters

The GetCapabilities request parameters are FORMAT, VERSION, SERVICE, REQUEST and UPDATESEQUENCE (cf. Table 1). The usage is equivalent to the ISO/DIS 19128 Web Map Service standard.

7.2.4.GetCapabilities response

7.2.4.1 General

When invoked on a Web 3D Service, the response to a GetCapabilities request shall be an XML document containing service metadata formatted according to the XML Schema in A.1.

The schema specifies the mandatory and optional content of the service metadata and how the content is formatted. The response shall be valid according to XML Schema validation rules.

The GetCapabilities response description is identical to the one from the ISO/DIS 19128 Web Map Service standard. Following are particular variations to the ISO standard:

7.2.4.2 Exceptions

Upon receiving an invalid operation request, the W3DS will respond to the client using an Exception Report message to describe to the client application and/or its human user the reason that the request is invalid. The service will handle exceptions as described in clause 8 of the OWS Common Implementation Specification.

7.2.4.3 Layers

Although the W3DS is a portrayal service like WMS the layer concept is treated differently. See section 7.3.2.15 for further explanation.

7.3 GetScene (mandatory)

7.3.1 General

The GetScene operation returns a 3D scene graph. Upon receiving a GetScene request, a W3DS shall either satisfy the request or issue a service exception.

The required parameters for the 3D visualization of a scene by a W3DS are the instruction to request a scene (REQUEST=GetScene), the selected spatial reference system (parameter SRS), the delimitation of the geographical area selected by an enclosing rectangle (bounding box, parameter BBOX), the desired output format, as well as parameters for the definition of a predefined virtual camera. The perspective can be defined in a similar fashion like in the WTS:

a) Point of Interest (POI): the exact location in x,y,z space of the viewer's focus.

b) Distance: the distance between the viewer and the POI in meters.

c) Pitch: the angle or inclination (in degrees) between the viewer and the POI (0º means the viewer is looking horizontally and -90º means the viewer is looking straight down on the POI).

d) Yaw: azimuth, the angle representing the "head swivel" (0º faces due north, 90º faces due east, etc.).

e) Angle of view (AOV): The angle representing the breadth of landscape in the viewer's scene.

f) Also commonly described as the field of view or field of vision. Corresponds to the width of the scene intersecting the POI.

The volume of the scene can be limited by MINHEIGHT and MAXHEIGHT.

The WTS allows the implicit selection of the displayed range by providing only the parameters POI, DISTANCE, AOV as well as YAW and PITCH, calculating the visible area from these parameters (without indicating a bounding box). For a W3DS this approach is not feasible, because the position coordinate values of 3D objects are moved to a new origin. This translation is needed because some SRS generate very high coordinate values, e.g. 8 digits in UTM, which do not bare enough capacity for submeter precison. The new origin is defined by *xmin* and *ymin* of the bounding box. Practically this means the W3DS substracts from every 3D coordinate of the first coordinate axis *xmin* and from the second *ymin*. If BBOX would be an optional parameter and omitted in a request, the W3DS would have to compute *xmin* and *ymin*. However, different W3DS implementations could calculate different values for the same camera parameters. This would make the integration of the output of different W3DS in the same scene impossible, because each produced scene graph would have its own origin.

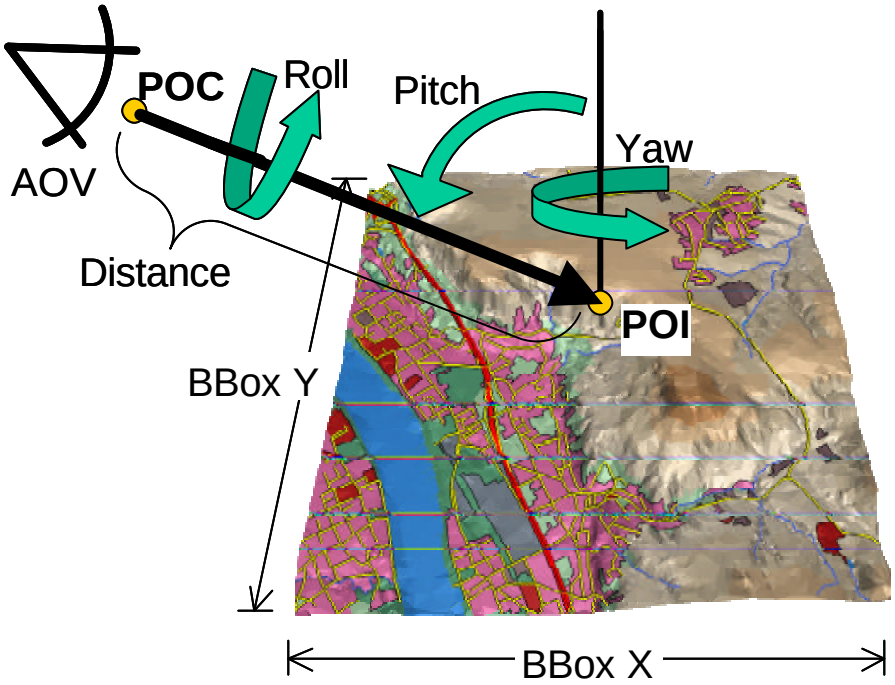

Figure 4 — The different viewing parameters of the GetScene request

The viewing parameters are adopted and enhanced from the WTS draft specification (V0.5.0). There are many possibilities to specify a virtual camera that is used as initial perspective. Figure 4 shows the different viewing parameters for the W3DS. They are listed in Table 2 and are described in the following paragraphs.

Additionally the W3DS will do an axes transformation from real world to computer graphics coordinate systems. Real world coordinates (like UTM, Gauss Kruger or geographical coordinates) are typically using left-hand Cartesian coordinate system with z indicating the height above sea level. Computer graphics coordinate systems (like in VRML) are usually based on a right-hand Cartesian coordinate system. Therefore a W3DS automatically changes the axes of the real world SRSs as shown in Figure 5.

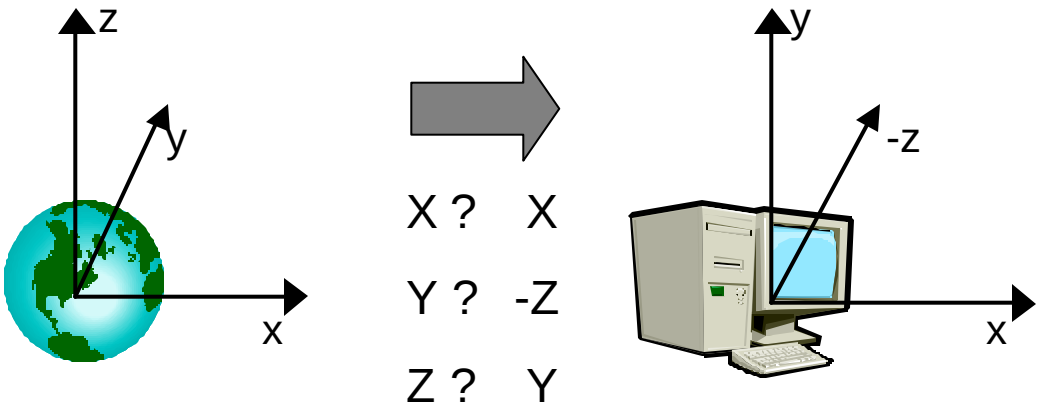

Figure 5 — Axes transformation from real world coordinates (left) to 3D computer graphics coordinate system (right)

7.3.2 GetScene request

7.3.2.1 Parameters

The GetScene request is the main operation of a W3DS. The basic usage is described in OGC's OWS specification and is corresponding to the GetMap request of the ISO/DIS 19128 Web Map Service standard.

Table 2 shows the parameters for a GetScene request. Parameters marked with "R" are mandatory, "O" means they are optional and "C" is conditional, i.e. the usage of the conditional rated parameters depends on the required or optional parameters.

Table 2 — Parameters of the GetScene request

URL parameter	Required/ Optional/ Conditional	annotation
VERSION=<*version*>	R	requested version
REQUEST=GetScene	R	requested operation
SRS=namespace:identifier	R	spatial reference system
POI=<*point_of_interest*>	C	x,y,z point coordinates according to SRS
PITCH=<*pitch*>	C	angle of inclination [degree]
YAW=<*yaw*>	C	azimuth [degrees]
ROLL=<*roll*>	O	rotation around viewing vector [degree]
DISTANCE=<*distance*>	C	distance POI to POC [meter]

POC=x, y, z	C	x,y,z coordinates of camera according to SRS
AOV=<*angle_of_view*>	C	angle of view [degree]
BBOX=*xmin,ymin,xmax,ymax*	R	2d bounding box
MINHEIGHT=<*lower_limit*>	O	displaying objects with height ≥ *lower_limit* according to SRS
MAXHEIGHT=<*upper_limit*>	**O**	displaying objects with height ≤ *upper_limit* according to SRS
LAYERS=<*layer list*>	O	comma separated list of 3D object sets
STYLES=<*style list*>	O	comma separated list of styles for each layer
FORMAT=<*format*>	R	MIME type of output
TIME=<*date_and_time*>	O	date and time
EXCEPTIONS=<*excepttype*>	O	exception format
TRANSLATE=*x,y,z*	C	translation vector that is applied to all 3D coordinates
ENVIRONMENT=on / off	O	switch on/off background elements like sky or light source
BGCOLOR=<*color*>	O	background color
BGIMAGE=<*image url*>	O	URL of background image

7.3.2.2 VERSION

The REQUEST parameter will be used as described in the ISO/DIS 19128 Web Map Service standard. Valid values are “0.1.0” and “0.3.0”. Version negotiation is described in clause 6.2.

7.3.2.3 REQUEST

The REQUEST parameter will be used as described in the ISO/DIS 19128 Web Map Service standard and discussed in clause 6.3. Usage: REQUEST=GetScene

7.3.2.4 SRS

The parameters for the spatial reference system (SRS) is defined in the ISO/DIS 19128 Web Map Service standard and the WTS 0.5.0 specification. When using a 2D SRS height is measured in meters above sea level.

7.3.2.5 POI

POI=x,y,z designates the target point for the virtual camera, that is used as initial viewpoint. The coordinate values refer to the spatial reference system named by the SRS parameter. The use of POI is conditional and may be used only in conjunction with other parameters (for valid parameter combinations check the examples in appendix B.1).

7.3.2.6 PITCH

PITCH defines the angle of inclination measured in degree. The up and downward looking is made possible by this angle. PITCH=0 means horizontal line of sight, negative values are for looking down – for looking up positive values are used. Values range from -90 to 90.

The use of PITCH is conditional and may be used only in conjunction with other parameters (for valid parameter combinations check the examples in appendix B.1). If POI is indicated, PITCH is interpreted in accordance with the WTS 0.5.0 specification. If the POC parameter is used, PITCH refers to the angle of inclination of the camera. PITCH shall not be provided, if both POI and POC are contained in the parameter list.

7.3.2.7 YAW

YAW defines the azimuth of the line of sight in degrees. The rotation around the vertical axis is defined by this angle. YAW=0 means the view to the north.

The use of YAW is conditional and may be used only in conjunction with other parameters. If POI is indicated, YAW is interpreted in accordance with the WTS 0.5.0 specification. If the POC parameter is used, YAW refers to the angle of rotation of the camera. YAW shall not be indicated, if both POI and POC are contained in the parameter list (for valid parameter combinations check the examples in appendix B.1).

7.3.2.8 ROLL

ROLL indicates the angle of rotation of the camera around the view axis (the distance from the camera main point to the target) in degrees. The values ranges from -180 to 180. A positive angle corresponds to a turn to the left. If ROLL is not indicated, then the default value of 0 degrees (horizontal) is assumed.

7.3.2.9 DISTANCE

The DISTANCE parameter indicates the distance between camera (viewer) and the POI in meters. A value of 0 means the viewer is right at the place of the POI. DISTANCE may be only indicated if the POI parameter is and the POC parameter is not provided (for valid parameter combinations check the examples in appendix B.1).

This parameter is described in the WTS 0.5.0 specification, too.

7.3.2.10 POC

With POC=x, y, z the point of camera (POC) can be specified whereby the coordinate values refer to the reference system indicated in the SRS parameter. For the clear specification of a viewing perspective the camera coordinates must be used either in connection with the parameter POI or the parameters PITCH, YAW and DISTANCE. POC, POI and the parameters PITCH, YAW and DISTANCE may not be indicated all at the same time (for valid parameter combinations check the examples in appendix B.1).

7.3.2.11 AOV

AOV determines the angle of view of the viewer measured in degrees. In conjunction with the POC parameter it designates the aperture angle in accordance with the VRML97 specification for *FieldOfView* at the explanation of the viewpoint nodes. If only the POI parameter is indicated, AOV has the same meaning as in the WTS 0.5.0 specification.

7.3.2.12 BBOX

The bounding box concept of the W3DS is handled like the one described in the ISO/DIS 19128 Web Map Service standard. Bounding box values specify the portion of the Earth to be mapped through two pairs of coordinates in a specified layer coordinate reference system (Layer CRS). The first pair specifies the minimum coordinate values in the Layer CRS, the second specifies maximum coordinate values. The usage of the BBOX parameter is:

```
BBOX=xmin,ymin,xmax,ymax
```

where xmin<xmax and ymin<ymax. The coordinate values of BBOX are referring to spatial reference system provided at the SRS parameter. 3D objects that lay only partially within the bounding box shall be contained in the returned scene. No prescription is done whether the objects are cut at the bounding limits or if they are completely entered into the scene. An additional request parameter concerning this problem may be introduced in the future.

The BBOX parameter is mandatory.

7.3.2.13 MINHEIGHT

By indicating a minimum height the selection of the displayed objects can be further limited. Only objects and/or partial objects are displayed, whose elevation coordinate values are larger or equal to the indicated elevation value. If MINHEIGHT is omitted, there is no restriction of the elevation coordinate values downward. MINHEIGHT refers to the original elevation coordinates of the real world objects before any translation or other transformation takes place.

7.3.2.14 MAXHEIGHT

The MAXHEIGHT parameter is analogous to MINHEIGHT but refers to objects whose elevation coordinate values are lower or equal to the indicated elevation value.

7.3.2.15 LAYERS

The LAYERS parameter specifies a comma separated list of layers to be displayed. The concept of the layer is a metaphor to the traditional (two-dimensional) cartography, with which geo objects of different classes were drawn on different foils resulting in a map with an overall view of this foils. The sequence of the layers defines which kinds of object cover the others. While this makes sense for 2-dimensional maps of the WMS and the 2,5d representation of the WTS, the sequence of layers in the 3D does not have a meaning, since the visibility depends on the viewer's point of view, only.

Apart from the drawing sequence, layers are employed to group objects. Thus, layers are used as a synonym for sets of different graphical 3D elements. By using layers, the type of objects can be selected. For example in a 3D city model the W3DS makes digital terrain models (DTM), buildings street furniture or vegetation individually addressable. Unlike to the WTS all layers are equitable 3D objects.

If the parameter is not indicated the W3DS decides which data will be delivered to the client.

This parameter is described in the ISO/DIS 19128 Web Map Service standard.

7.3.2.16 STYLES

This parameter specifies for each layer, in which style it is to be illustrated on the graphics elements. The available styles are predifined by a W3DS and listed individually for each layer in the capabilities document. The STYLES parameter contains a comma separated list of the desired styles and it shall only be indicated if the layer parameter is given, too. The number of styles must correspond to the number of indicated layers. For using of default styles leave blank.

Example:

`LAYERS=dtm,buildings,vegetation&STYLES=orthophoto,,simple`

selects layers for a digital terrain model (DTM), buildings and vegetation, where the DTM is covered with an orthophoto, the buildings are displayed in default styles (blank parameter) and the vegetation's style is "simple".

This parameter is described in the ISO/DIS 19128 Web Map Service standard.

7.3.2.17 FORMAT

This parameter specifies the output format of the service as indicated in the capabilities document. All W3DS shall provide model/vrml. At present other feasible formats are GeoVRML and X3D. These formats are optional.

Table 3 — Feasible output formats

Format	MIME Type	support
VRML97	model/vrml	mandatory
X3D	model/x3d+xml	optional
GeoVRML	model/vrml	optional

7.3.2.18 TIME

With the time parameter the specific time or timeframe of visualization can be defined. A concrete date with a certain time can be selected. Thus, the position of the sun can be reconstructed (among other things) and appropriate scene lighting can be generated. Furthermore the TIME parameter can be used by the W3DS also for the selection of certain time-dependent data.

The specification of valid parameter values is in accordance with the ISO standard 8601 are described in the ISO/DIS 19128 Web Map Service standard in appendix D.

Example: TIME=2003-10-25T14:28:43Z identifies the 25th of October 2003 at 14:28 hours und 43 seconds. The added Z abbreviates „Zulu“ time which is equivalent to UTC.

7.3.2.19 EXCEPTIONS

With the EXCEPTIONS parameter a client indicates, in which way he would like to be referred to errors or exceptional cases. Two different possibilities are specified in the following. Closer information for the treatment of errors and exceptions is given in section 6.7 of the ISO/DIS 19128 Web Map Service standard.

Please note that due to serious network problems or crash of a server sometimes the client may not get an answer on a request. A W3DS client should be prepared for this possibility, too.

g) EXCEPTIONS=application/vnd.ogc.se_xml (default)
In the case of an error a XML document is sent to the Client, which contains an error description. The structure of this XML document is described in appendix A.2.

h) EXCEPTIONS=application/vnd.ogc.se_blank
In the case of an error a response in the demanded format is generated, which contains no graphic elements, i.e. no visual representation is produced. This "silent failure" is meaningful when a large number of W3DS are integrated.

7.3.2.20 TRANSLATE

Depending on the used SRS coordinate values of 3D objects may become very high. For example the Gauss Kruger System needs seven digits before the decimal point for meters and two digits after the decimal point for accuracy in centimetres. Since most 3D viewers are using floating point number with single precision (32 bit) (which means they are significant in 8 digits only), there will be visible errors in the visualisation because of imprecise rounding.

TRANSLATE=x,y,z defines an offset to the three coordinate axes which will be added to the coordinate values to shrink them for a better handling. Integer and floating point numbers are allowed values for x,y,z .

If the TRANSLATE parameter is omitted, the W3DS will automatically calculate an offset based on the BBOX parameter and subtracts it from the coordinate values. If TRANSLATE is indicated no automatic translation will be done.

7.3.2.21 ENVIRONMENT

A W3DS may decide to add additional graphical elements to a generated scene, like light sources or background images, for a more realistic looking presentation. However, if the output from different W3DSs should be merged more than one environment could be irritating. So with the ENVIRONMENT parameter backgrounds etc. can be switched on or off for each request.

7.3.2.22 BGCOLOR

With the BGCOLOR parameter the background colour of the scene can be specified, if the output format selected by FORMAT supports this option.

The color value is coded hexadecimal: 0xRRGGBB, where RR is the red, GG the green and BB the blue value from 00 to FF (0-255 decimal). While the hexadecimal numbers may be indicated in large or small letters, the "x" of the prefix must be small case.

7.3.2.23 BGIMAGE

With BGIMAGE the URL of a raster image can be posted to the W3DS, which is embedded or referenced in the returned scene as background image. A typical application is the indication of an image illustrating the scene's sky. It depends thereby among other things on the selected output format whether and how this parameter is to be considered.

7.3.3 GetScene response

The response to a valid GetScene request is a 3D scene graph of the specified geographical area in the requested format and spatial reference system, whereby the 3D coordinates are accordingly moved by the BBOX offset or the TRANSLATE parameter. Additionally coordinate axis will be shifted to computer graphics coordinate axis as shown in figure 4.

A scene graph is a general data structure commonly used by vector-based graphics editing applications. The scene graph contains the pictorial data items being organized in a tree structure. Each node in a scene graph represents some atomic unit of the document[1]. For further reading about interactive 3D computer graphics [5] is recommended.

If one or more layers were specified, then the scene shows only the objects, which are contained in these layers. If styles were indicated to these layers, then the objects of the individual layers are portrayed according to the respective style. If the output format allows the possibility of camera definition, a default camera is contained in the resulting file, whose placement is derived from the provided view parameters. If the resulting file contains references to further files e.g. textures, then it must be ensured that these files are accessible over the Internet.

In case of an incorrect request or an occurring error while generating the scene, the response must be supplied in the requested format for exceptional cases (parameters EXCEPTION) by the server. With a request via HTTP the MIME type of the returned document must be set by the server according to contents of the resulting file.

---

[1] Taken from Wikipedia http://en.wikipedia.org/wiki/Scene_graph. For further reading see or ISO/IEC 14772 and ISO/IEC FDIS 19775 and [5].

Annex A
(normative)

XML schemas

A.1 W3DS capabilities schema

This is the XML Schema fragment for encoding a generic GetCapabilities operation request is:

```
<?xml version="1.0" encoding="UTF-8"?>
<W3DS_Capabilities version="0.3.0" xmlns="http://www.opengis.net/w3ds"
xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.opengis.net/w3ds
http://schemas.opengis.net/w3ds/0.3.0/W3DS_capabilities_0_3_0.xsd">
   <!-- Service Metadata -->
   <Service>
      <!-- The WMT-defined name for this type of service -->
      <Name>W3DS</Name>
      <!-- Human-readable title for pick lists -->
      <Title>IKG Web 3D Server</Title>
      <!-- Narrative description providing additional information -->
      <Abstract>Web 3D Server maintained by Institue for Cartography and
Geoinformation, University of Bonn.  Contact: quadt@ikg.uni-bonn.de. 3D
City models of Bonn including buildings, roads, street furniture,
vegetation and dtm in LOD4.</Abstract>
      <KeywordList>
         <Keyword>city model</Keyword>
         <Keyword>3D</Keyword>
         <Keyword>scene graph</Keyword>
      </KeywordList>
      <!-- Top-level web address of service or service provider.  See also
OnlineResource elements under  <DCPType>. -->
      <OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink"
xlink:type="simple" xlink:href="http://hostname/"/>
      <!-- Contact information -->
      <ContactInformation>
         <ContactPersonPrimary>
            <ContactPerson>Udo Quadt</ContactPerson>
            <ContactOrganization>Institue for Cartography and
Geoinformation, University of Bonn</ContactOrganization>
         </ContactPersonPrimary>
         <ContactPosition>PhD student</ContactPosition>
         <ContactAddress>
            <AddressType>postal</AddressType>
            <Address>Meckenheimer Allee 172</Address>
            <City>Bonn</City>
            <StateOrProvince/>
            <PostCode>53115</PostCode>
            <Country>Germany</Country>
         </ContactAddress>
         <ContactVoiceTelephone>+49 228 73 6334</ContactVoiceTelephone>
```



```
         <ContactElectronicMailAddress>quadt@ikg.uni-
bonn.de</ContactElectronicMailAddress>
      </ContactInformation>
      <!-- Fees or access constraints imposed. -->
      <Fees>none</Fees>
      <AccessConstraints>none</AccessConstraints>
   </Service>
   <Capability>
      <Request>
         <GetCapabilities>
            <Format>text/xml</Format>
            <DCPType>
               <HTTP>
                  <Get>
                     <OnlineResource
xmlns:xlink="http://www.w3.org/1999/xlink"
xlink:type="simple" xlink:href="http://hostname/path?"/>
                  </Get>
                  <Post>
                     <OnlineResource
xmlns:xlink="http://www.w3.org/1999/xlink"
xlink:type="simple" xlink:href="http://hostname/path?"/>
                  </Post>
               </HTTP>
            </DCPType>
         </GetCapabilities>
         <GetScene>
            <Format>model/vrml</Format>
            <Format>model/x3d+xml</Format>
            <DCPType>
               <HTTP>
                  <Get>
                     <!-- The URL here for invoking GetScene using HTTP GET
            is only a prefix to which a query string is appended. -->
                     <OnlineResource
xmlns:xlink="http://www.w3.org/1999/xlink"
xlink:type="simple" xlink:href="http://hostname/path?"/>
                  </Get>
               </HTTP>
            </DCPType>
         </GetScene>
      </Request>
      <Exception>
         <Format>XML</Format>
         <Format>BLANK</Format>
      </Exception>
      <Layer>
         <Title>IKG Web 3D Server</Title>
         <CRS>CRS:84</CRS>
            <EX_GeographicBoundingBox>
               <westBoundLongitude>7.037</westBoundLongitude>
               <eastBoundLongitude>7.200</eastBoundLongitude>
               <southBoundLatitude>50.650</southBoundLatitude>
               <northBoundLatitude>50.770</northBoundLatitude>
            </EX_GeographicBoundingBox>
         <!-- all layers are available in at least this CRS -->
         <AuthorityURL name="DIF_ID">
```



```
            <OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink"
xlink:type="simple"
xlink:href="http://www.ikg.uni-bonn.de/w3ds/ID_maker.html"/>
         </AuthorityURL>
         <!--Example layer of a digital terrain model including a style-->
         <Layer>
            <Name>DTM</Name>
            <Title>Digital Terrain Model of Bonn, Germany</Title>
            <CRS>EPSG:31466</CRS>
            <BoundingBox CRS="EPSG:31466" minx="2598000" miny="5684000"
maxx="2610000" maxy="5696000" />
            <Style>
               <Name>DTMstyle</Name>
               <Title>Example style for a DTM</Title>
               <Abstract>This is an example style for a typical
DTM</Abstract>
            </Style>
         </Layer>
         <!--Example layer for buildings-->
         <Layer>
            <Name>BUILDINGS</Name>
            <Title>3D Model of buildings of the Univerity of Bonn</Title>
            <CRS>EPSG:31466</CRS>
            <BoundingBox CRS="EPSG:31466" minx="2598000" miny="5684000"
maxx="2610000" maxy="5696000" />
            <Style>
               <Name>plain</Name>
               <Title>Plain facade of buildings</Title>
            </Style>
            <Style>
               <Name>textured</Name>
               <Title>Textured facade layed on building</Title>
            </Style>
         </Layer>
      </Layer>
   </Capability>
</W3DS_Capabilities>
```

A.2 Service exception schema

```
<?xml version="1.0" encoding="UTF-8"?>
<xsd:schema targetNamespace="http://www.opengis.net/ogc"
xmlns:xsd="http://www.w3.org/2001/XMLSchema"
xmlns:ogc="http://www.opengis.net/ogc" elementFormDefault="qualified">
   <xsd:element name="ServiceExceptionReport">
      <xsd:complexType>
         <xsd:sequence>
            <xsd:element name="ServiceException"
type="ogc:ServiceExceptionType" minOccurs="0" maxOccurs="unbounded"/>
         </xsd:sequence>
         <xsd:attribute name="version" type="xsd:string" fixed="0.3.0"/>
      </xsd:complexType>
   </xsd:element>
   <!--A list of possible exception codes will be provided in the future-->
   <xsd:complexType name="ServiceExceptionType">
      <xsd:simpleContent>
         <xsd:extension base="xsd:string">
```



```
            <xsd:attribute name="code" type="xsd:string"/>
            <xsd:attribute name="locator" type="xsd:string"/>
         </xsd:extension>
      </xsd:simpleContent>
   </xsd:complexType>
</xsd:schema>
```

Annex B
(informative)

Examples

B.1 Example requests of GetScene operation (URL)

Example 1
Get a scene constrained by a bounding box (BBOX) without specific initial view point. The SRS EPSG:31466 specifies Gauss Kruger coordinates (UTM projection) in 2nd Central Meridian (Germany). The coordinates are manually moved by (-2580000, -5720000, 0).

```
http://www.myserver.de/W3DS?VERSION=0.3.0&REQUEST=GetScene&SRS=EPSG:
      31466&FORMAT=model/vrml&BBOX=2583150,5720600,2584000,5722000&TR
      ANSLATE=-2580000,-5720000,0
```

Example 2
The view is defined by a point-of-interest (POI), the viewing angles PITCH and YAW, the distance to the camera and its angle-of-view (AOV).

```
http://www.myserver.de/W3DS?VERSION=0.3.0&REQUEST=GetScene&SRS=EPSG:
      31466&FORMAT=model/vrml&POI=2583150.0,5720600.0,52.5&PITCH=45&Y
      AW=45&DISTANCE=100&AOV=90&BBOX=2583150,5720600,2584000,5722000
```

Example 3
The view is calculated from a point-of-interest (POI), the point-of-camera (POC) and the angle-of-view (AOV).

```
http://www.myserver.de/W3DS?VERSION=0.3.0&REQUEST=GetScene&SRS=EPSG:
      31466&FORMAT=model/vrml&POI=2583150.0,5720600.0,52.5&POC=255438
      4.38,5676500,100&AOV=90&BBOX=2583150,5720600,2584000,5722000
```

Example 4
The view is calculated from a point-of-camera (POC), the concerned viewing angles PITCH and YAW and the angle-of-view (AOV).

```
http://www.myserver.de/W3DS?VERSION=0.3.0&REQUEST=GetScene&SRS=EPSG:
      31466&FORMAT=model/vrml&POC=2554384.38,5676500,100&AOV=90&YAW=2
      3&PITCH=-45&BBOX=2583150,5720600,2584000,5722000
```

Example 5
The view is defined by a point-of-interest (POI), the concerned viewing angles PITCH and YAW, the distance to the camera and the angle-of-view (AOV).


```
http://www.myserver.de/servlet/W3DS?VERSION=0.3.0&REQUEST=GetScene&S
      RS=EPSG:31466&FORMAT=model/vrml&BBOX=2583150,5720600,2584000,57
      22000&POI=2583150.0,5720600.0,52.5&PITCH=45&YAW=45&DISTANCE=100
      &AOV=90
```

B.2 Example request of GetCapabilities operation (URL)

Example request to get the capabilities of the W3DS. Example taken and modified from the OWS Common Implementation:

```
http://myserver.de/W3DS?SERVICE=W3DS&REQUEST=GetCapabilities&FORMAT=
      text/xml
```

B.3 Sample W3DS service metadata (XML)

```
<?xml version="1.0" encoding="UTF-8"?>
<W3DS_Capabilities version="0.3.0" xmlns="http://www.opengis.net/w3ds"
xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.opengis.net/w3ds
http://schemas.opengis.net/w3ds/0.3.0/W3DS_capabilities_0_3_0.xsd">
   <!-- Service Metadata -->
   <Service>
      <!-- The WMT-defined name for this type of service -->
      <Name>W3DS</Name>
      <!-- Human-readable title for pick lists -->
      <Title>IKG Web 3D Server</Title>
      <!-- Narrative description providing additional information -->
      <Abstract>Web 3D Server maintained by Institue for Cartography and
Geoinformation, University of Bonn.  Contact: quadt@ikg.uni-bonn.de. 3D
City models of Bonn including buildings, roads, street furniture,
vegetation and dtm in LOD4.</Abstract>
      <KeywordList>
         <Keyword>city model</Keyword>
         <Keyword>3D</Keyword>
         <Keyword>scene graph</Keyword>
      </KeywordList>
      <!-- Top-level web address of service or service provider.  See also
OnlineResource
  elements under <DCPType>. -->
      <OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink"
xlink:type="simple" xlink:href="http://hostname/"/>
      <!-- Contact information -->
      <ContactInformation>
         <ContactPersonPrimary>
            <ContactPerson>Udo Quadt</ContactPerson>
            <ContactOrganization>Institue for Cartography and
Geoinformation, University of Bonn</ContactOrganization>
         </ContactPersonPrimary>
         <ContactPosition>PhD student</ContactPosition>
         <ContactAddress>
            <AddressType>postal</AddressType>
            <Address>Meckenheimer Allee 172</Address>
            <City>Bonn</City>
```

```
            <StateOrProvince/>
            <PostCode>53115</PostCode>
            <Country>Germany</Country>
         </ContactAddress>
         <ContactVoiceTelephone>+49 228 73 6334</ContactVoiceTelephone>
         <ContactElectronicMailAddress>quadt@ikg.uni-
bonn.de</ContactElectronicMailAddress>
      </ContactInformation>
      <!-- Fees or access constraints imposed. -->
      <Fees>none</Fees>
      <AccessConstraints>none</AccessConstraints>
   </Service>
   <Capability>
      <Request>
         <GetCapabilities>
            <Format>text/xml</Format>
            <DCPType>
               <HTTP>
                  <Get>
                     <OnlineResource
xmlns:xlink="http://www.w3.org/1999/xlink" xlink:type="simple"
xlink:href="http://hostname/path?"/>
                  </Get>
                  <Post>
                     <OnlineResource
xmlns:xlink="http://www.w3.org/1999/xlink" xlink:type="simple"
xlink:href="http://hostname/path?"/>
                  </Post>
               </HTTP>
            </DCPType>
         </GetCapabilities>
         <GetScene>
            <Format>model/vrml</Format>
            <Format>model/x3d+xml</Format>
            <DCPType>
               <HTTP>
                  <Get>
                     <!-- The URL here for invoking GetScene using HTTP GET
            is only a prefix to which a query string is appended. -->
                     <OnlineResource
xmlns:xlink="http://www.w3.org/1999/xlink" xlink:type="simple"
xlink:href="http://hostname/path?"/>
                  </Get>
               </HTTP>
            </DCPType>
         </GetScene>
      </Request>
      <Exception>
         <Format>XML</Format>
         <Format>BLANK</Format>
      </Exception>
      <Layer>
         <Title>IKG Web 3D Server</Title>
         <CRS>CRS:84</CRS>
            <EX_GeographicBoundingBox>
               <westBoundLongitude>7.037</westBoundLongitude>
               <eastBoundLongitude>7.200</eastBoundLongitude>
```



```
               <southBoundLatitude>50.650</southBoundLatitude>
               <northBoundLatitude>50.770</northBoundLatitude>
            </EX_GeographicBoundingBox>
         <!-- all layers are available in at least this CRS -->
         <AuthorityURL name="DIF_ID">
            <OnlineResource xmlns:xlink="http://www.w3.org/1999/xlink"
xlink:type="simple" xlink:href="http://www.ikg.uni-
bonn.de/w3ds/ID_maker.html"/>
         </AuthorityURL>
         <!--Example layer of a digital terrain model including a style-->
         <Layer>
            <Name>DTM</Name>
            <Title>Digital Terrain Model of Bonn, Germany</Title>
            <CRS>EPSG:31466</CRS>
            <BoundingBox CRS="EPSG:31466" minx="2598000" miny="5684000"
maxx="2610000" maxy="5696000" />
            <Style>
               <Name>DTMstyle</Name>
               <Title>Example style for a DTM</Title>
               <Abstract>This is an example style for a typical
DTM</Abstract>
            </Style>
         </Layer>
         <!--Example layer for buildings-->
         <Layer>
            <Name>BUILDINGS</Name>
            <Title>3D Model of buildings of the Univerity of Bonn</Title>
            <CRS>EPSG:31466</CRS>
            <BoundingBox CRS="EPSG:31466" minx="2598000" miny="5684000"
maxx="2610000" maxy="5696000" />
            <Style>
               <Name>plain</Name>
               <Title>Plain facade of buildings</Title>
            </Style>
            <Style>
               <Name>textured</Name>
               <Title>Textured facade layed on building</Title>
            </Style>
         </Layer>
      </Layer>
   </Capability>
</W3DS_Capabilities>
```

B.4 Sample service exception (XML)

```
<?xml version="1.0" encoding="UTF-8"?>
<ServiceExceptionReport version="0.3.0" xmlns="http://www.opengis.net/ogc"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.opengis.net/ogc
http://schemas.opengis.net/w3ds/0.3.0/exceptions_0_3_0.xsd">
   <ServiceException>
Plain text message about an error.
</ServiceException>
   <ServiceException code="InvalidUpdateSequence">
Another error message, this one with a service exception code supplied.
</ServiceException>
```

```
   <ServiceException><![CDATA[
Error in module <foo.c>, line 42

A message that includes angle brackets in text
must be enclosed in a Character Data Section
as in this example.  All XML-like markup is
ignored except for this sequence of three
closing characters:
]]></ServiceException>
   <ServiceException><![CDATA[
<Module>foo.c</Module>
<Error>An error occurred</Error>
<Explanation>Similarly, actual XML
can be enclosed in a CDATA section.
A generic parser will ignore that XML,
but application-specific software may choose
to process it.</Explanation>
]]></ServiceException>
</ServiceExceptionReport>
```

Bibliography

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