Bancos de Dados Geográficos

Curso de Verão - Geoinformática

27 de Janeiro de 2020

Geo Web Services

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World Wide Web

- No final dos anos 90 presenciamos sua evolução:
  - De simples páginas com conteúdo estático, para páginas com conteúdos dinâmicos, extraídos, principalmente, de Sistemas Gerenciadores de Bancos de Dados (SGBDs)

- Tecnologias que emergiram no final da década passada:
  - Common Gateway Interface (CGI)
  - Active Server Pages (ASP)
  - Java Server Pages (JSP)
  - Hypertext Preprocessor (PHP)
  - ...

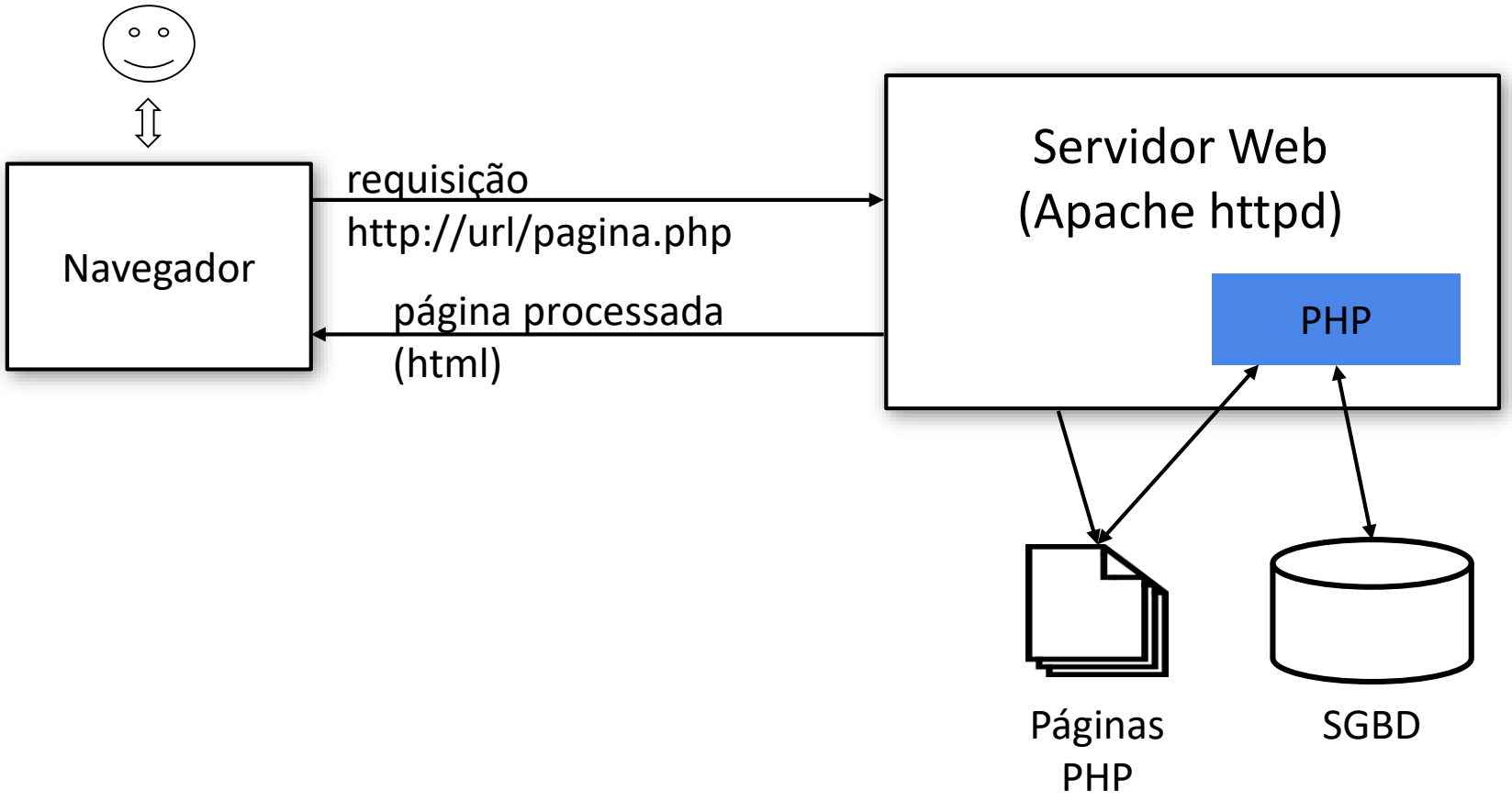
Páginas Dinâmicas PHP: Acessando o SGBD

```
<html>
 <body>
  <?php
        $conexao = pg_connect("host=localhost port=5432 dbname=bdgeo
                user=postgres password=tdk696");
        $query  = "SELECT codmuni, nommuni, AsText(the_geom) FROM mg_municipios";
        $resultado = pg_query($conexao, $query);
        $nlinhas = pg_num_rows($resultado);
        print("<table>\n");
        print("<tr><td><b>Código IBGE</b></td>
         <td><b>Nome Município</b></td>
         <td><b>Limite</b></td></tr>");
        for($i = 0; $i < $nlinhas; ++$i)
        {       $codigo_municipio = pg_fetch_result($resultado, $i, 0);
                $nome_municipio = pg_fetch_result($resultado, $i, 1);
                $limite_municipal = substr(pg_fetch_result(
                      $resultado, $i, 2), 0, 50) . "...";
               print("<tr><td>$codigo_municipio</td><td>$nome_municipio</td>
          <td>$limite_municipal</td></tr>");
        }

    print("</table>");
        pg_free_result($resultado);
   pg_close($conexao);
  ?>
 </body>
</html>
```

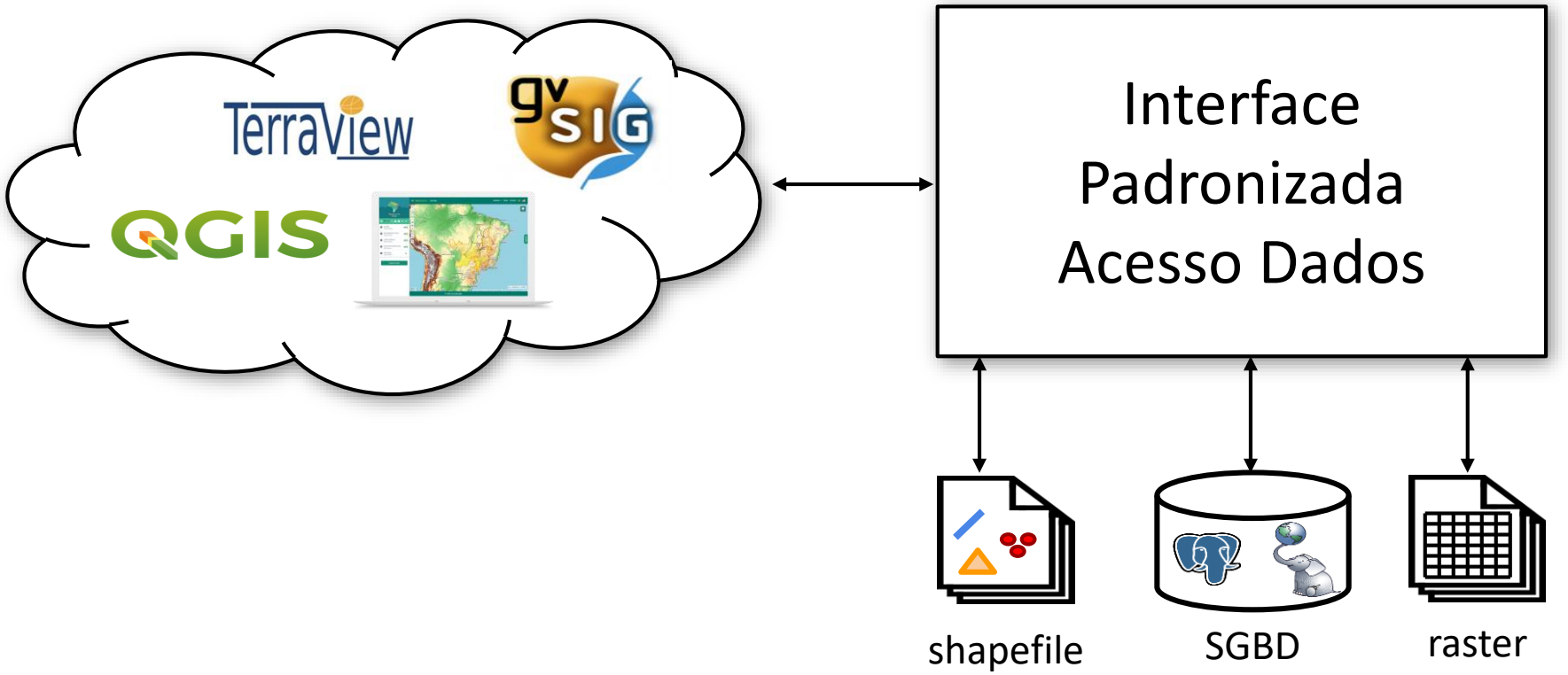
Saída Entregue ao Navegador

```
<html>
  <body>
    <table>
      <tr>
        <td><b>Código IBGE</b></td>
        <td><b>Nome Município</b></td>
        <td><b>Limite</b></td>
      </tr>
      <tr>
        <td>10</td>
        <td>Abadia dos Dourados</td>
        <td>MULTIPOLYGON(((-47.453025 -18.503637,-47.450258 -1...</td>
      </tr>
      ...
</body>
</html>
```

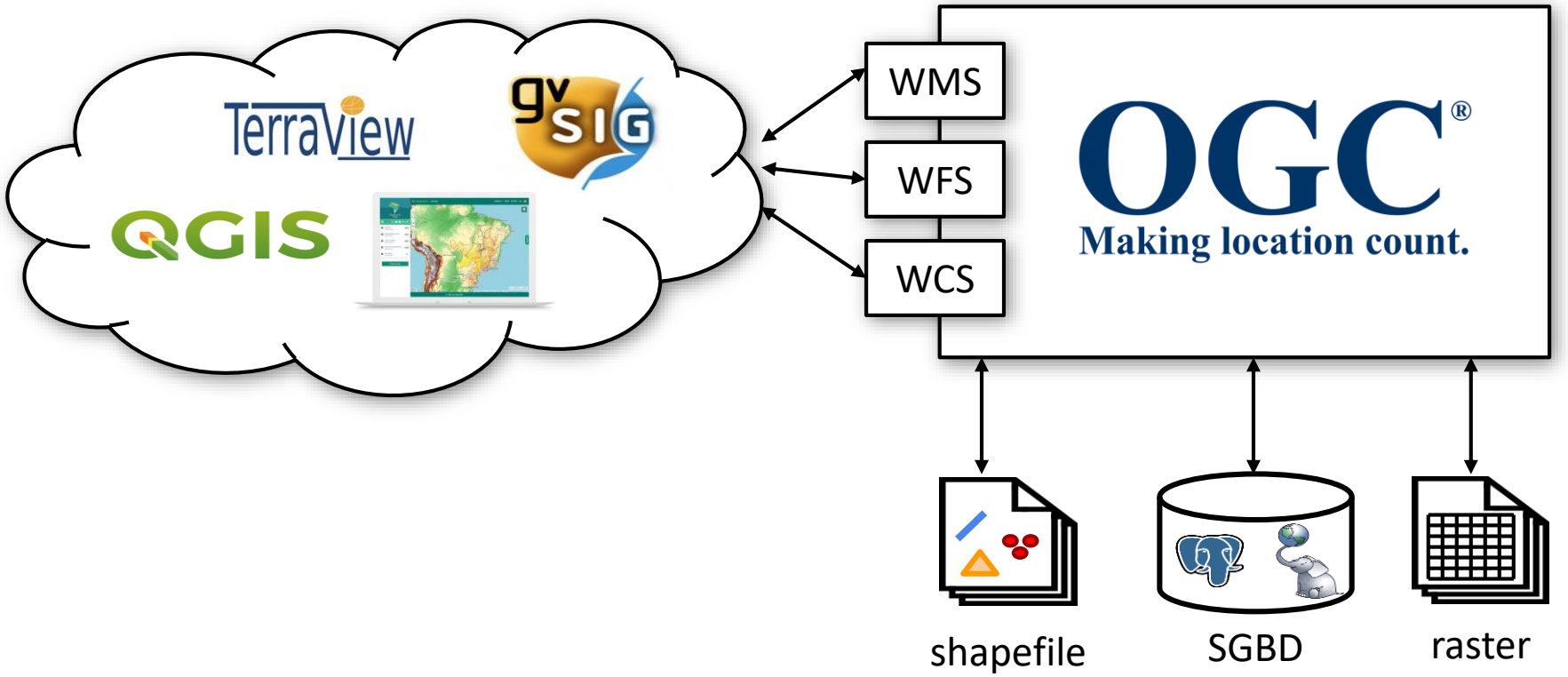
Arquitetura Tradicional



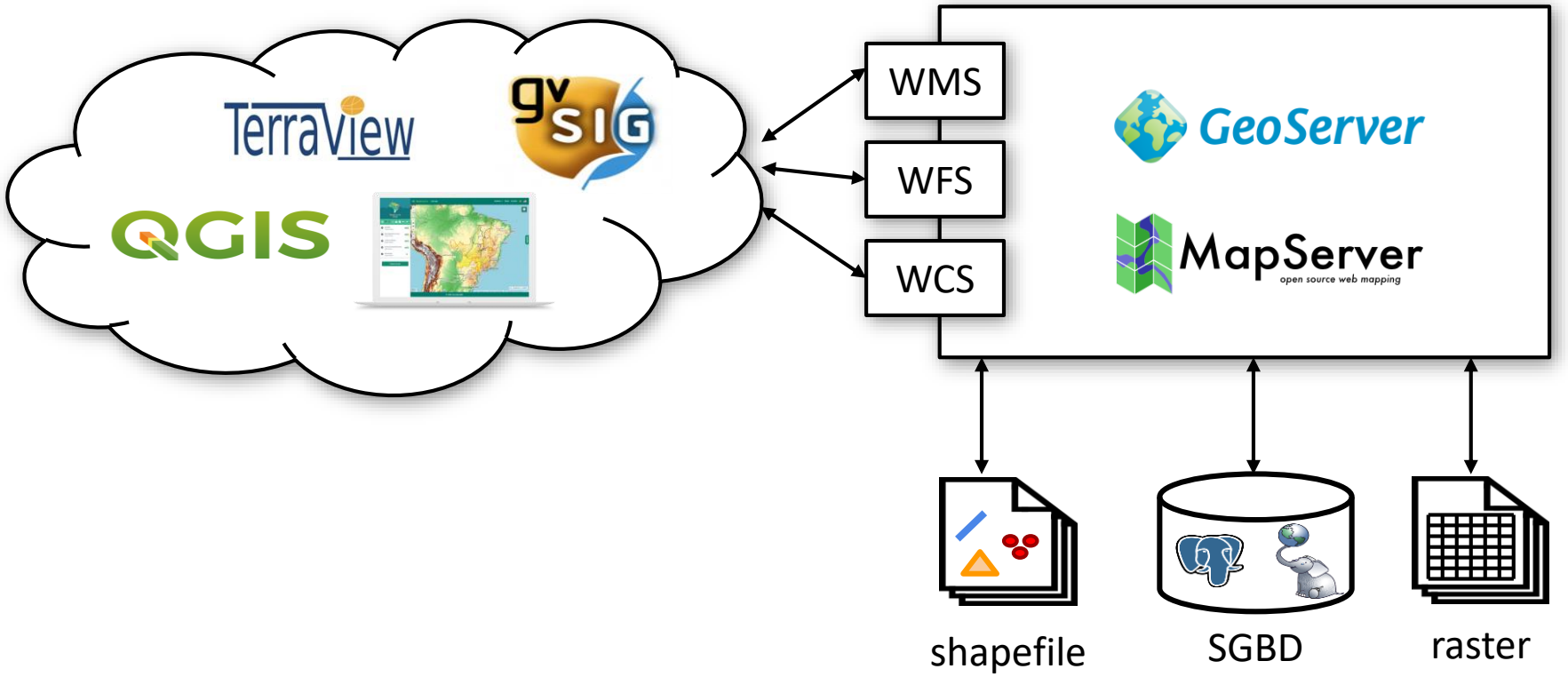
Interface de Acesso a Dados Geoespaciais



Interface de Acesso a Dados Geoespaciais



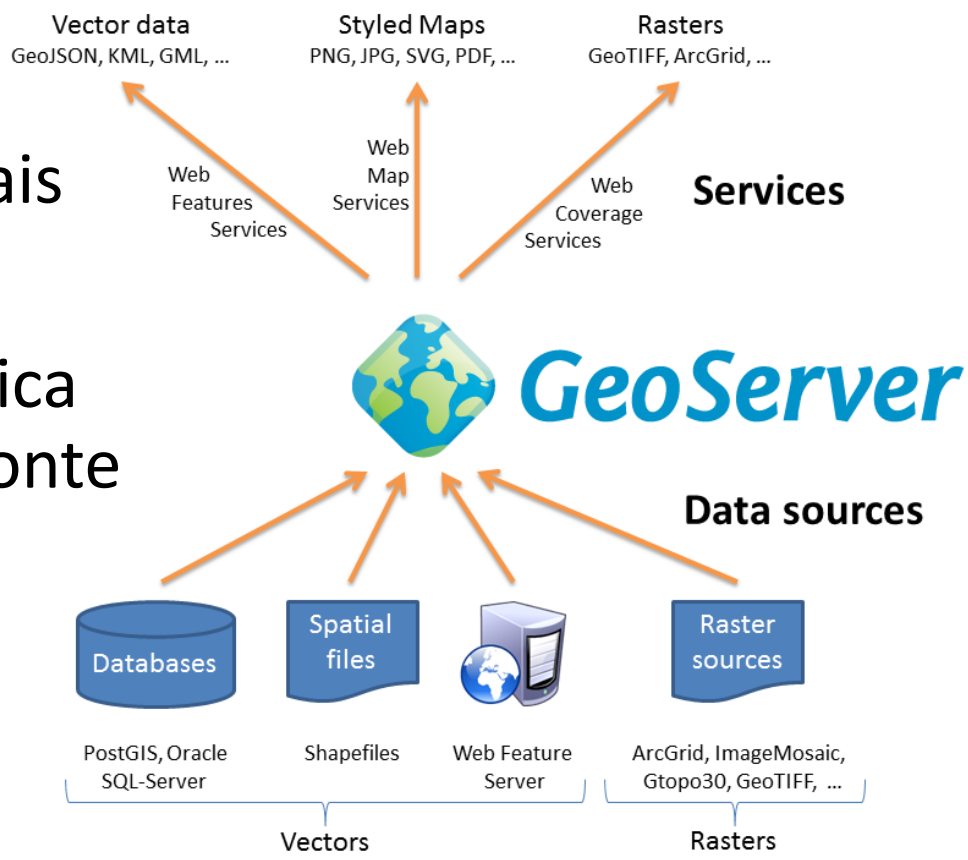
Interface de Acesso a Dados Geoespaciais



Prática: GeoServer

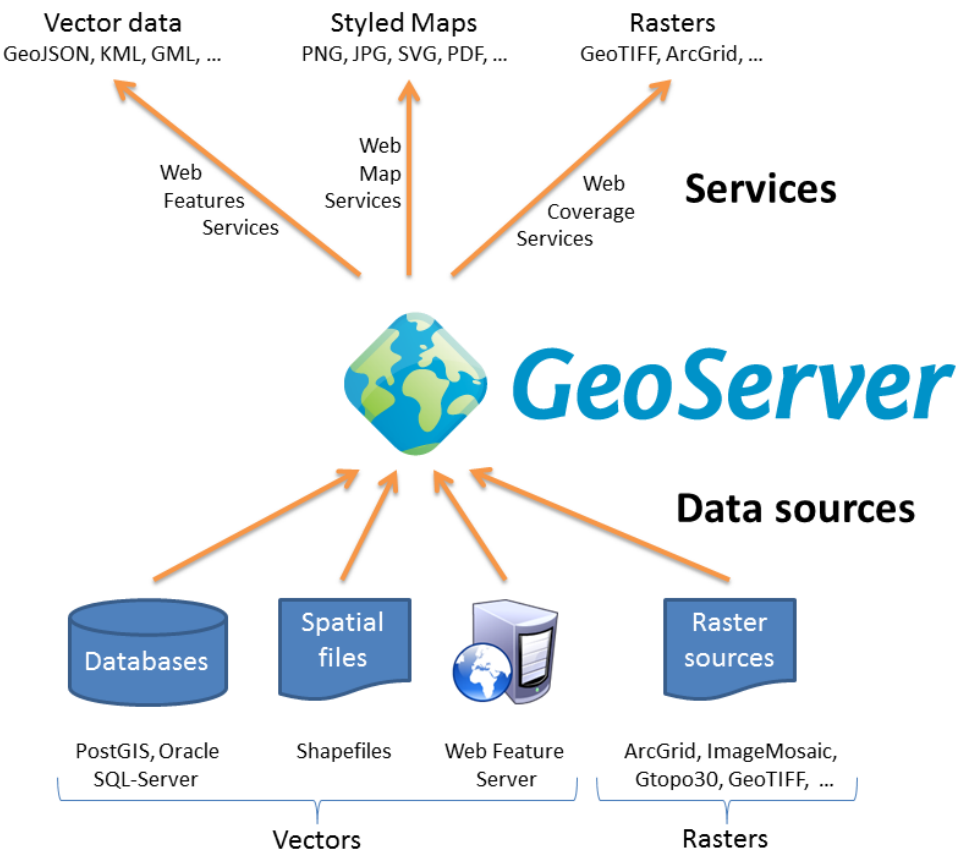
GeoServer

- Geoserver é um servidor de código aberto escrito em Java que permite aos usuários compartilhar e editar dados geoespaciais
- Projetado para a interoperabilidade pública de dados de qualquer fonte utilizando os principais padrões abertos



GeoServer

- Implementa padrões OGC: **WMS, WFS, WCS,** etc
- Utiliza SLD (Styled Layer Descriptor) para formatação de estilos

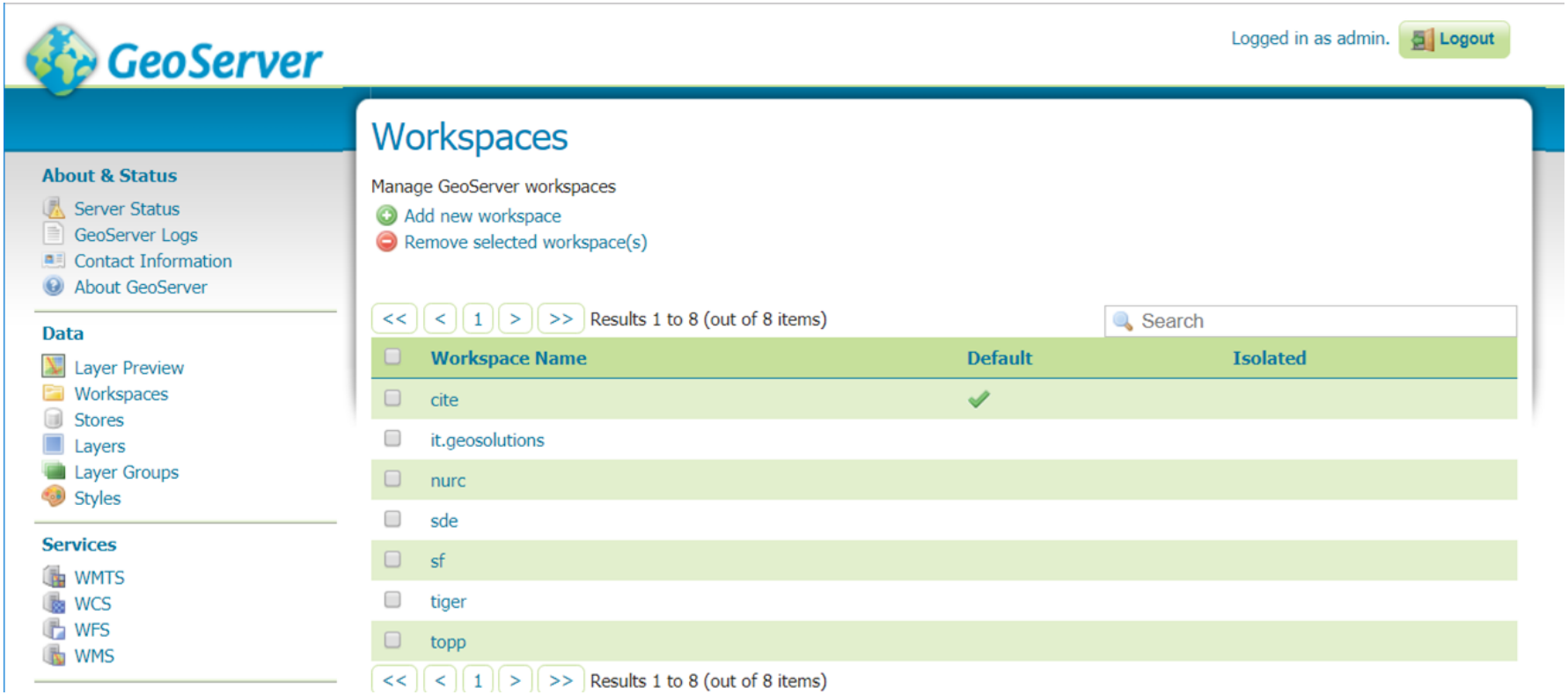


GeoServer

Quadro Resumo	
Site Oficial	http://geoserver.org/
Suporte	OSGeo
Código Fonte	Linguagem Java
API de Programação	REST API
Padrões OGC	SFS (PostGIS e Oracle Spatial)
	WMS, WFS, WMC, WCS,WPS, WMTS, CSW, SLD, GML, SOS
	TIFF/GeoTIFF, NetCDF, MrSID, ECW, outros via GDAL
	ESRI Shapfiles, PostGIS, SpatialLite, ESRI ArcSDE, Oracle Spatial, Mysql e outros via OGR

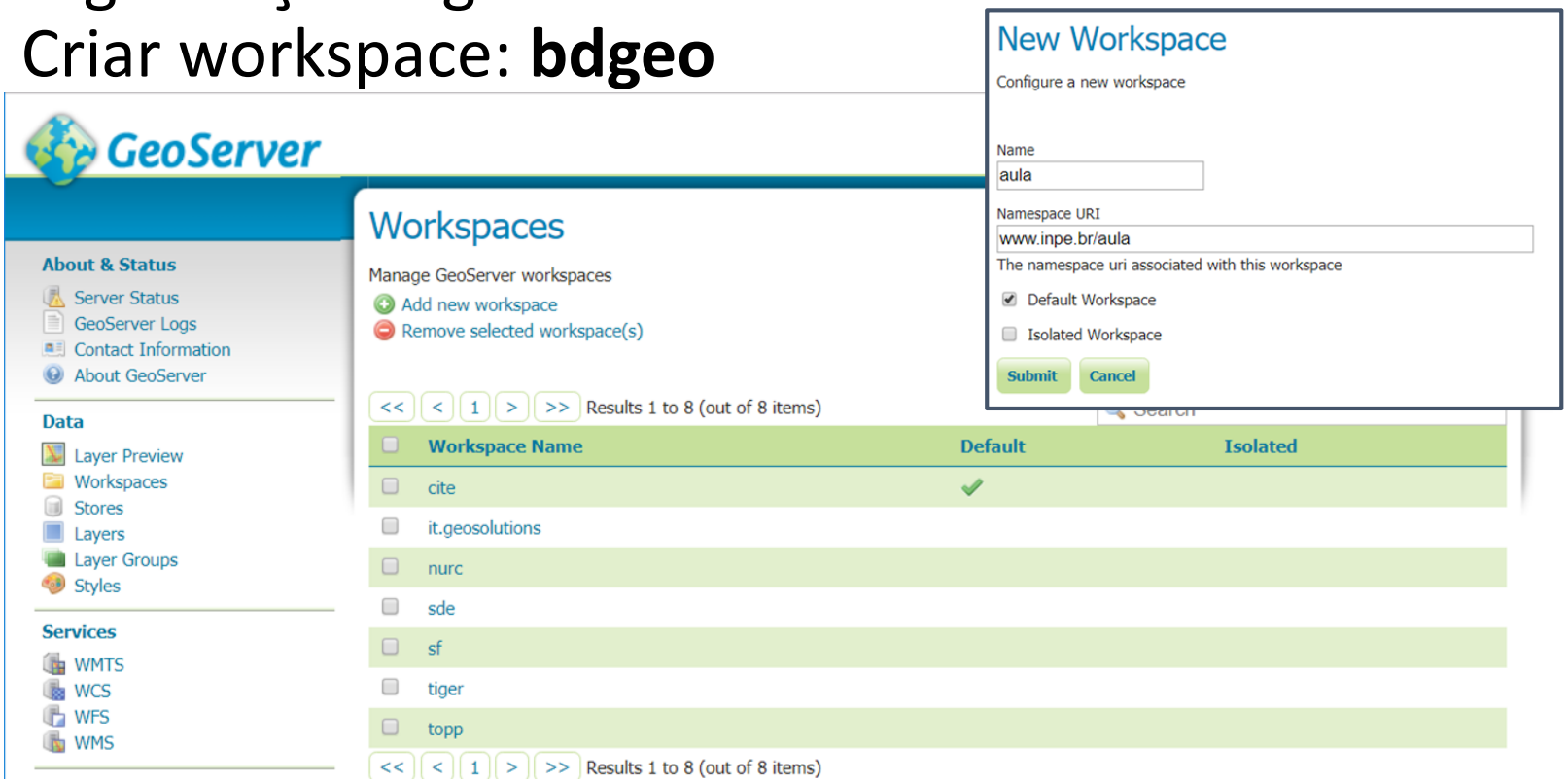
Geoserver - Prática

- **Workspaces**: espaço para organização lógica dos dados.
- Criar workspace: **bdgeo**



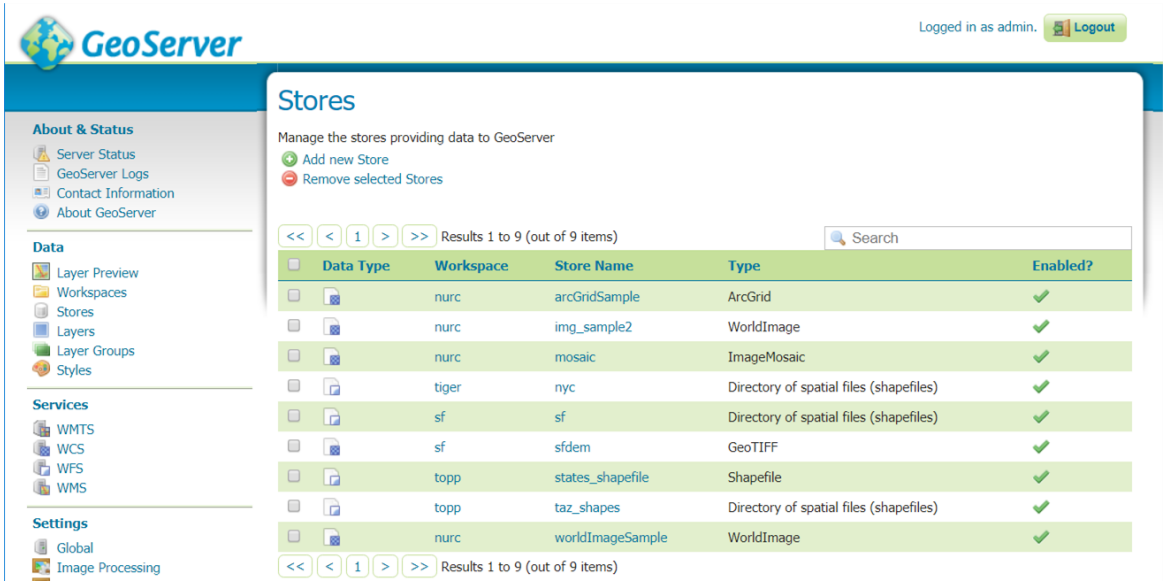
Geoserver - Prática

- **Workspaces**: espaço para organização lógica dos dados.
- Criar workspace: **bdgeo**



Geoserver - Prática

- **Stores**: conexão com as fontes de dados (arquivo, grupo de arquivos, tabela, etc)



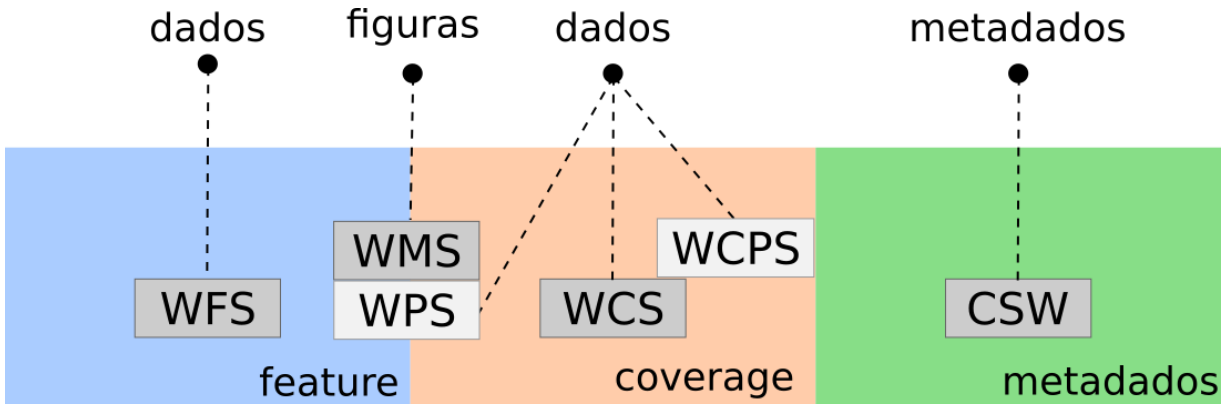
Type Icon	Description
	raster data in a file
	vector data in a file
	vector data in a database
	vector server (web feature server)

Geoserver - Prática

- **Stores**: conexão com as fontes de dados (arquivo, grupo de arquivos, tabela, etc)
- Abrir no **OpenLayers**

Store	**Store type**	**Path**
focos_2020	Shapefile	D:\Dados\focos_2020.shp
Uf	PostGIS	

OGC Web Services

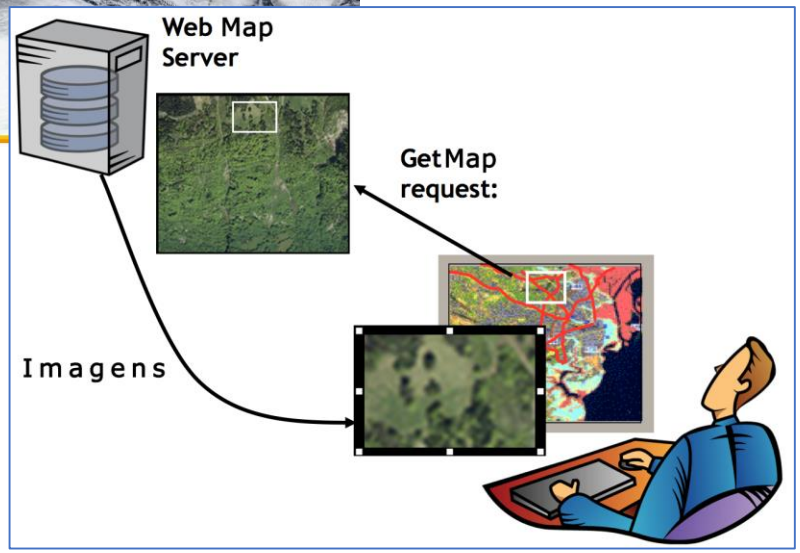


Fonte: Adaptado de Baumann (2010)

Web Map Service

WMS: Web Map Service

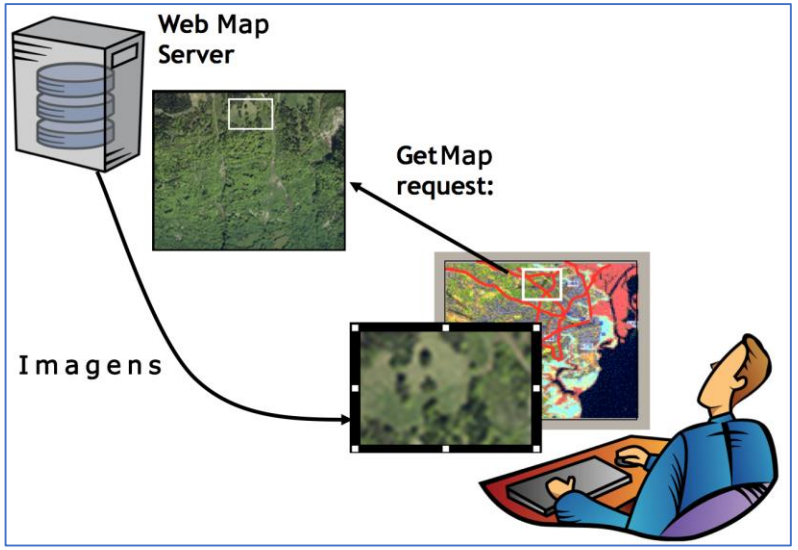
Especificação OGC para serviços de produção de Mapas na Web



WMS: Web Map Service

- Coverages e Features → Figuras
  - Disponibiliza imagens para visualização

- Requisições:
  - GetCapabilities
  - GetMap
  - GetFeatureInfo



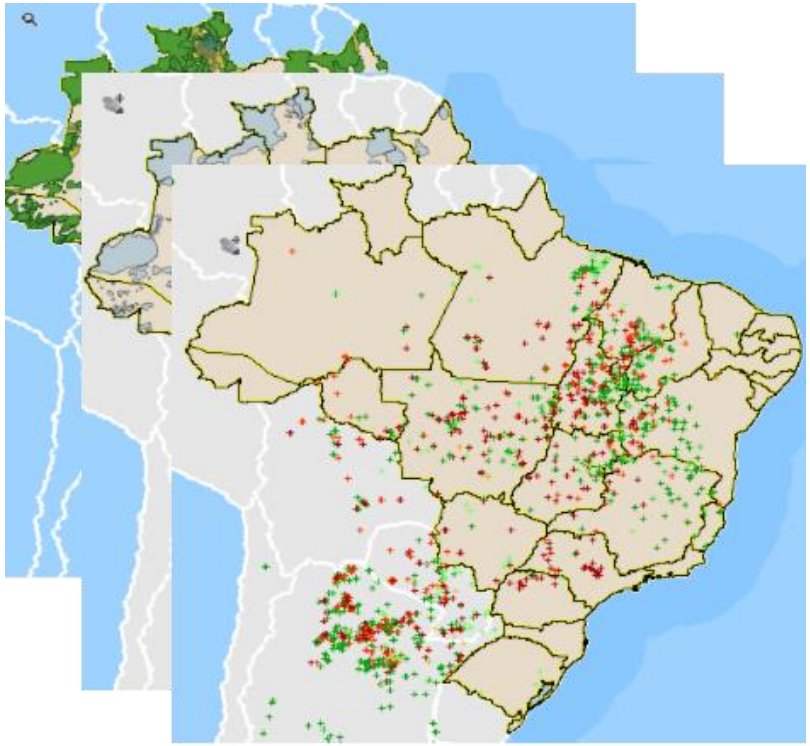
WMS: Aplicação

Ministério Meio Ambiente
(MMA): Florestas Nacionais

WMS: Aplicação

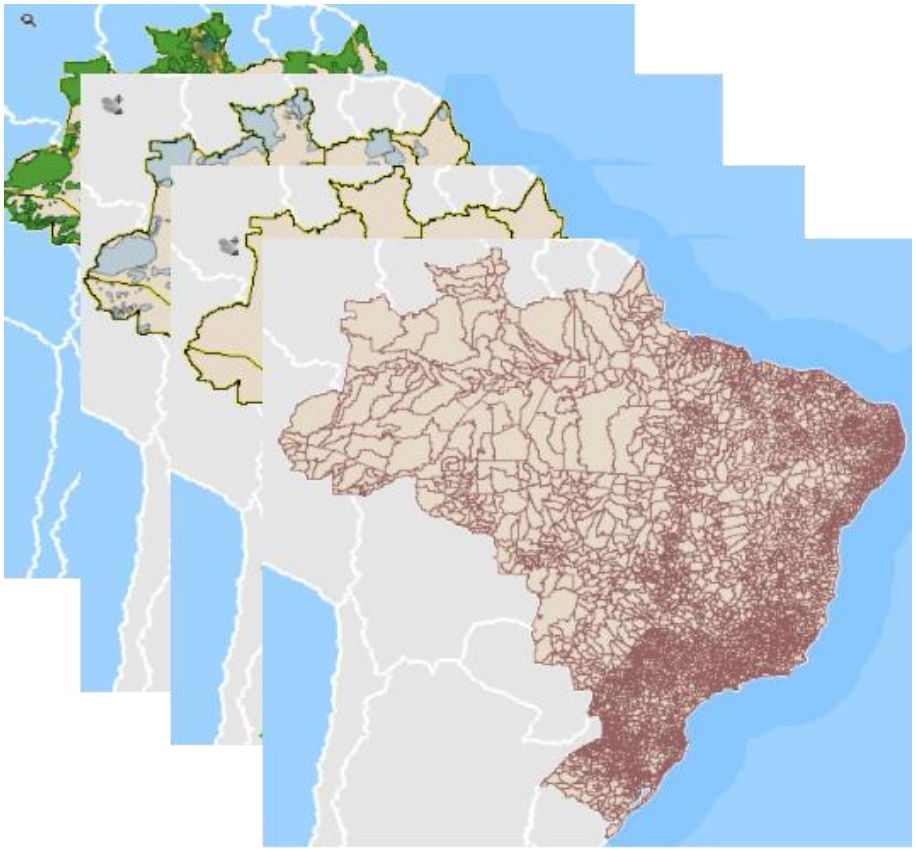
FUNAI
Terras Índigenas

WMS: Aplicação



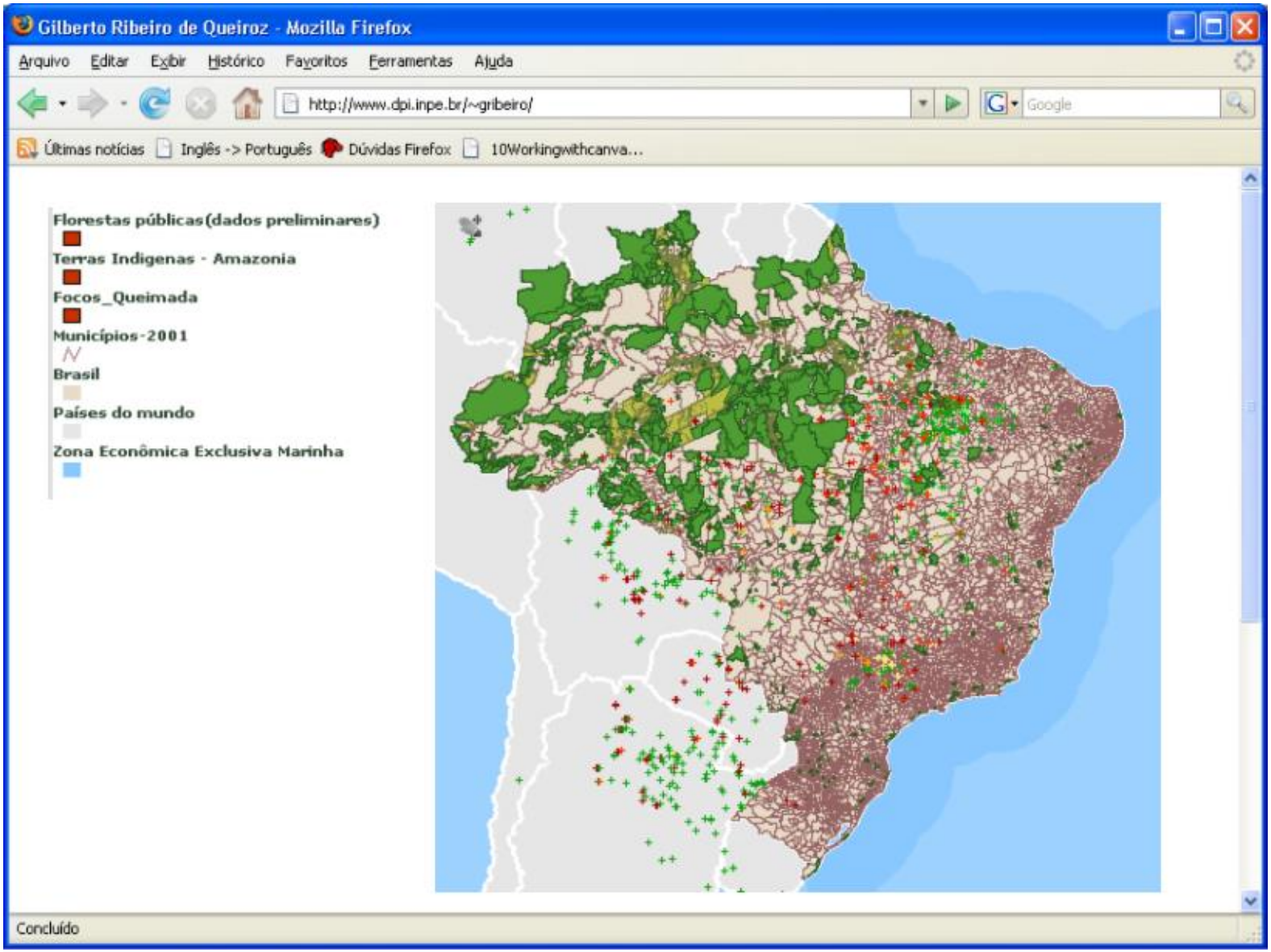
INPE/CPTEC
Focos Incêndio

WMS: Aplicação

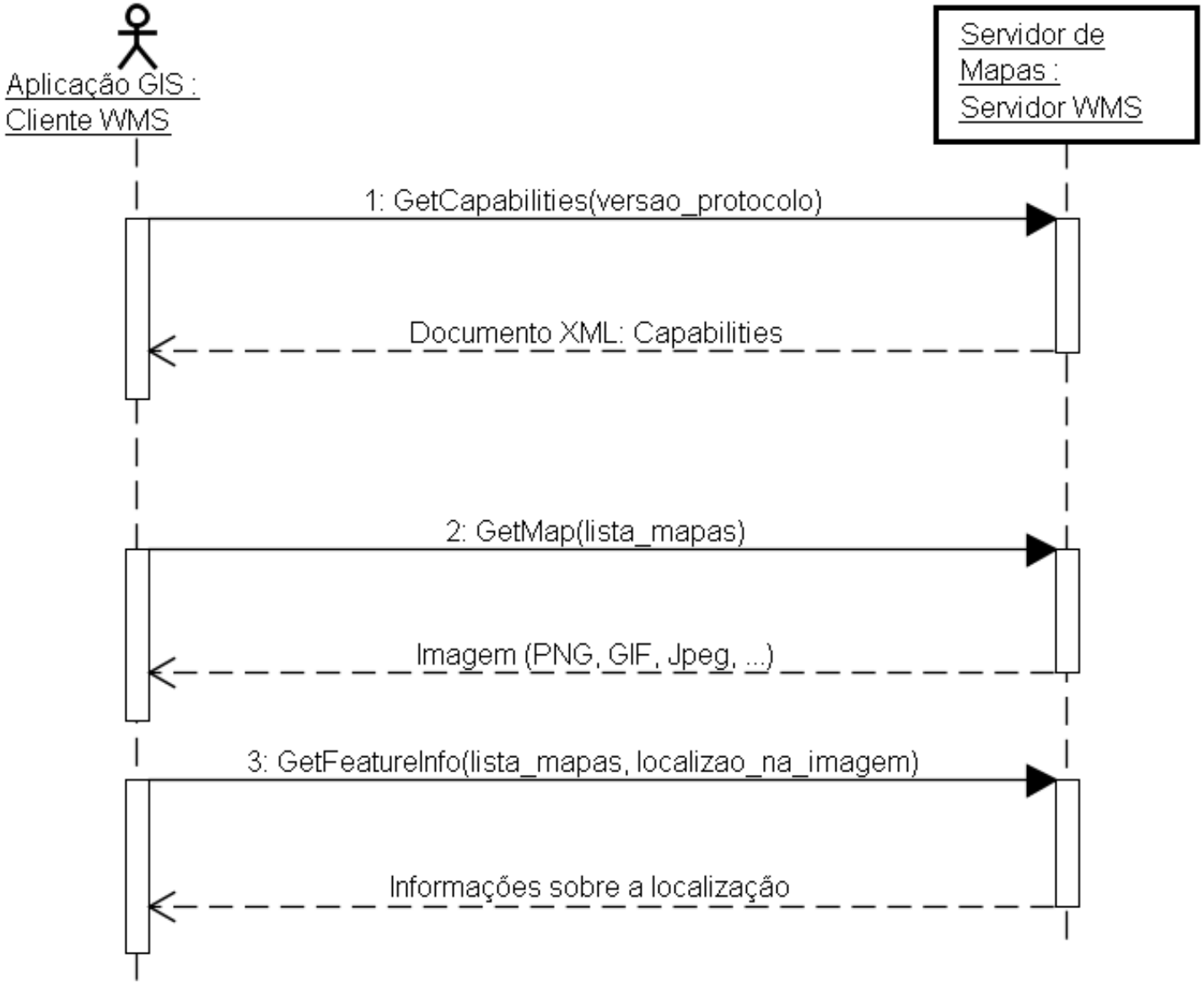


IBGE
Limites Municipais

WMS: Aplicação



WMS: Web Map Service



WMS: GetMap

```
url?service=wms&version=1.1.0&request=GetMap
&layers=map&srs=EPSG:32623&bbox=x0,y0,xf,yf
&width=800&height=600&format=image:png
```

Parâmetro	Valores	Requerido
service	wms	Sim
version	1.0.0, ... , 1.3.0	Sim
request	GetMap	Sim
layers	Lista separada por “,”	Sim
styles	Lista separada por “,”	Sim
srs ou crs	EPSG:nnnn	Sim

Parâmetro	Valores	Requerido
bbox	x0,y0,xf,yf	Sim
width	800	Sim
height	600	Sim
format	image/png, image/jpeg, ...	Sim
transparent	true, false	No
bgcolor	Default: #FFFFFF	No

https://docs.geoserver.org/latest/en/user/services/wms/reference.html

WMS: Prática

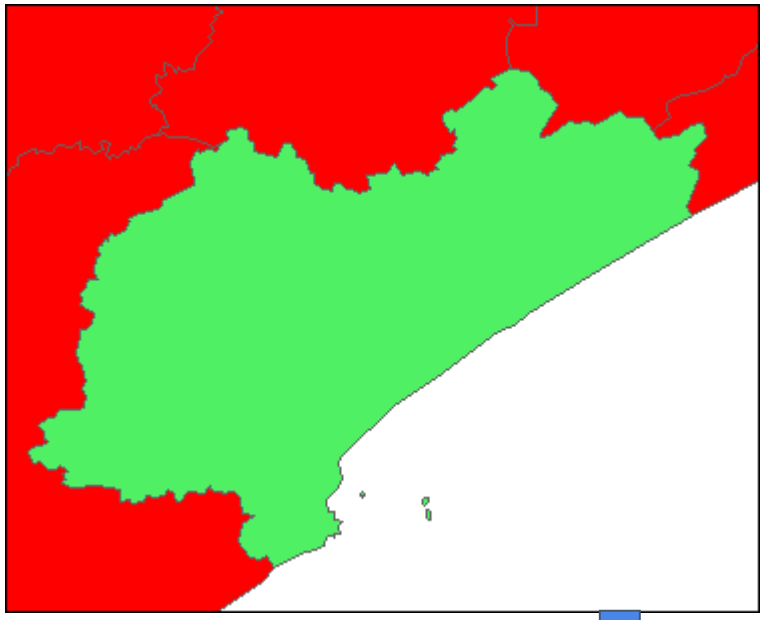
- Visualizar Layers criados
  - OpenLayers
  - GetCapabilities
  - DescribeLayer
  - GetMap
  - QGIS
  - Programa Queimadas

Geography Markup Language

```
<gml:coord>
  <gml:X>100</gml:X>
  <gml:Y>50</gml:Y>
</gml:coord>

<gml:pos>100 50</gml:pos>

<gml:coordinates>-45.3,-22.8 -47.4,-22.1</gml:coordinates>

<gml:posList>-45.3 -22.8 -47.4 -22.1</gml:posList>
```

```
<gml:posList srsDimension="2" srsName="EPSG:29193">
209875.37 7786108.83 209932.91 7785823.73 210330.08
7783858.70 209966.27 7781855.12
</gml:posList>
```

```
<gml:Point>
  <gml:pos srsDimension="2">326358.80 7397825.65
  </gml:pos>
</gml:Point>

<gml:Curve>
  <gml:segments>
    <gml:LineStringSegment>
      <gml:posList srsDimension="2">209875.37
7786108.83 209932.91 7785823.73 210330.08
7783858.70 209966.27 7781855.12
      </gml:posList>
    </gml:LineStringSegment>
  </gml:segments>
</gml:Curve>

<gml:LineString>
  <gml:coordinates>324576.16,7382767.53
324552.72,7382700.51 324504.21,7382669.83
324352.02,7382352.69</gml:coordinates>
</gml:LineString>
```



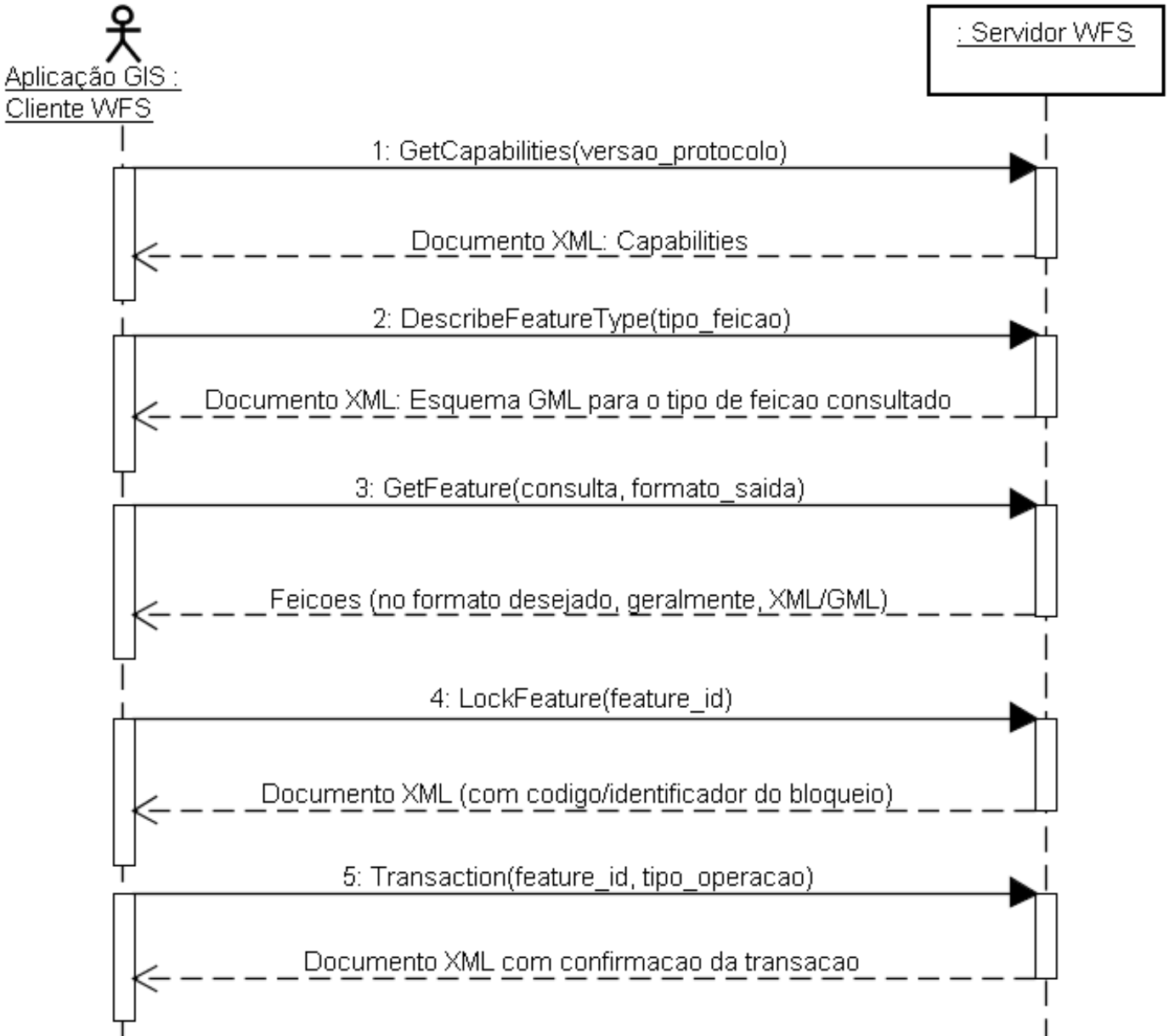
```
<microreg>
  <TeGeometry>
    <gml:MultiSurface srsName="EPSG:29193">
      <gml:surfaceMember>
        <gml:Surface>
          <gml:patches>
            <gml:PolygonPatch>
              <gml:exterior><gml:LinearRing>
                <gml:posList srsDimension="2">
                  263850.35 7309279.21 ...
                </gml:posList></gml:LinearRing>
              </gml:exterior>
            </gml:PolygonPatch>
          </gml:patches>
        </gml:Surface>
      </gml:surfaceMember>
      <gml:surfaceMember>  ...
        <gml:posList srsDimension="2">
          306642.38 7300712.22 ...
        </gml:posList>
        ...
      </gml:surfaceMember>
      ...
    </gml:MultiSurface>
  </TeGeometry>
  <nome>ITANHAEM</nome>
</microreg>
```

Web Feature Service

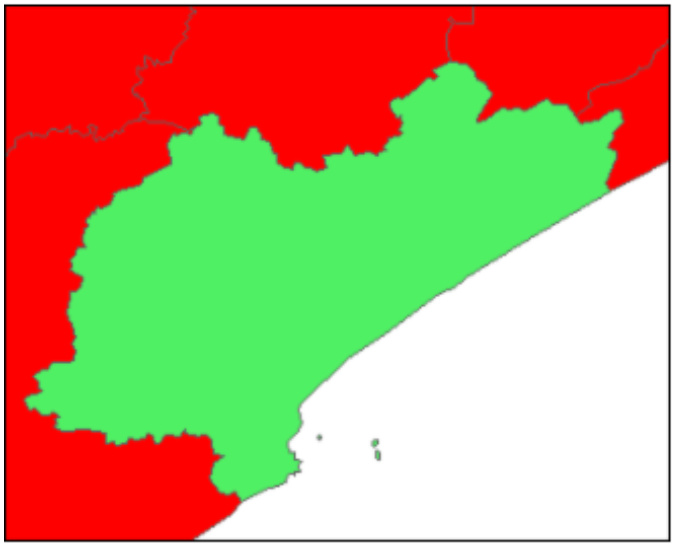
WFS: Web Feature Service

- WFS Básico:
  - ✓GetCapabilities:
  - ✓DescribeFeatureType
  - ✓GetFeature
- WFS Transacional (WFS-T):
  - ✓Transaction
  - ✓LockFeature (opcional)

WFS: Operações Suportadas



WFS: GML é o principal formato



```
<microreg>
  <TeGeometry>
    <gml:MultiSurface srsName="EPSG:29193">
      <gml:surfaceMember>
        <gml:Surface>
          <gml:patches>
            <gml:PolygonPatch>
              <gml:exterior>
                <gml:LinearRing>
                  <gml:posList srsDimension="2">
                    263850.35 7309279.21 ...
                  </gml:posList>
                </gml:LinearRing>
              </gml:exterior>
            </gml:PolygonPatch>
          </gml:patches>
        </gml:Surface>
      </gml:surfaceMember>
      <gml:surfaceMember>  ...
        <gml:posList srsDimension="2">
          306642.38 7300712.22 ...
        </gml:posList>
        ...
      </gml:surfaceMember>
      ...
    </gml:MultiSurface>
  </TeGeometry>
  <nome>ITANHAEM</nome>
</microreg>
```

WFS: Expressões usam Filter Encoding

```
<Filter>
   <Intersects>
      <PropertyName>Geometry</PropertyName>
      <gml:Polygon srsName="63266405">
         <gml:outerBoundaryIs>
            <gml:LinearRing>
               <gml:posList> … </gml:posList>
            </gml:LinearRing>
         </gml:outerBoundaryIs>
      </gml:Polygon>
   </Intersects>
</Filter>
```

OGC: Web Feature Service (WFS)

GetFeature:

```
url?service=wfs&version=2.0.0&request=GetFeature&typeNames=feature&propertyName=nome,populacao,uf&count=10&sortBy=nome+D&outputFormat=application/json
```

Parâmetro	Valores	Requerido
service	wfs	Sim
version	1.0.0, 1.1.0, 1.1.1, 1.3.0	Sim
request	GetFeature	Sim
typeNames	Lista separada por “,”	Sim
featureID	NNN	Não
maxFeatures	NNN (count: 2.0.0)	Não

Parâmetro	Valores	Requerido
sortBy	NomeAtributo(+A,+D)	Não
propertyName	Lista separada por “,”	Não
bbox	x0,y0,xf0,yf	Não
srsName	image/png, image/jpeg, ...	Não
transparent	CRS	Não
outputFormat	GML2, GML3, application/json	Não

https://docs.geoserver.org/latest/en/user/services/wms/reference.html

OGC: Web Feature Service (WFS)

- Visualizar Layers criados
  - OpenLayers
  - GetCapabilities: http://localhost:8080/geoserver/wfs?request=getCapabilities
  - DescribeFeatureType:
  - http://localhost:8080/geoserver/bdgeo/wfs?service=WFS&version=1.1.1&request=DescribeFeatureType&typeNames=bdego:uf
  - GetFeature:
  - http://localhost:8080/geoserver/bdgeo/wfs?service=WFS&version=1.1.1&request=GetFeature&typeNames=bdgeo:uf&count=10
  - QGIS

OGC: Web Feature Service (WFS) - Prática

- Extra:GetCapabilities com CQL_Filter:
  - http://localhost:8080/geoserver/bdgeo/wfs?service=WFS&version=1.1.1&request=GetFeature&typeName=bdgeo:uf&count=10&CQL_FILTER=uf:regiao='SUDESTE'
- Exercício:
  - **Obter as 2 maiores feições (área)**

Prática: GeoServer e QGIS

Web **C**overage **S**ervice

Web Coverage Service (WCS)

- Definição:

  Web Service descrito pelo OGC, cujo objetivo é obtenção e troca de informações espaciais sob a forma de coverages.

- Versões da Especificação:

  1.0.0: 27/08/2003, 03-065r6, 67 páginas

  1.1.0: 17/10/2006, 06-083r8, 143 páginas

WCS: Operações Suportadas

- GetCapabilities:

  Xml com os metadados do serviço e dos layers (coverages) oferecidos

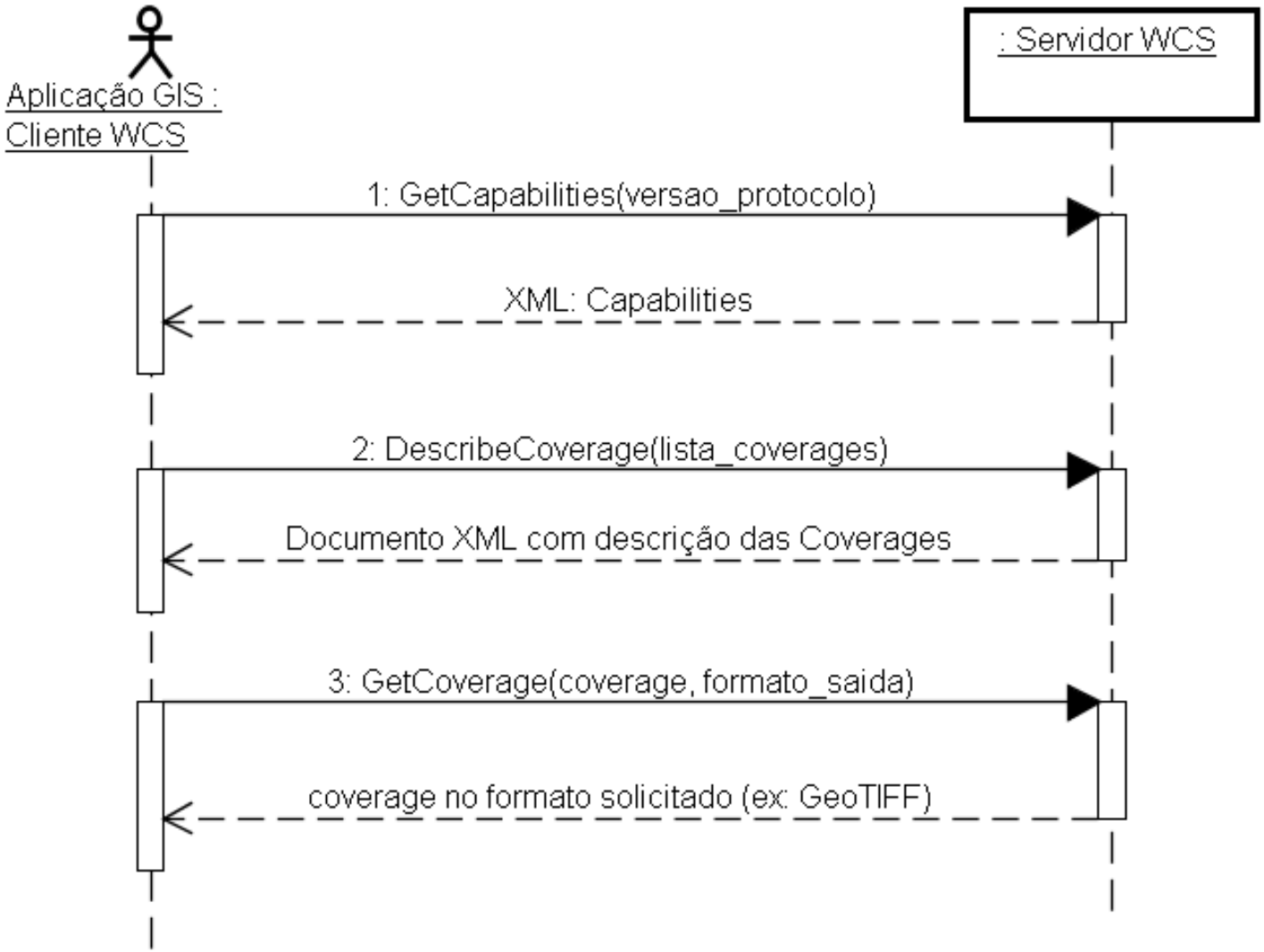
- DescribeCoverage:

  Xml detalhado da coverage

- GetCoverage:

  O dado propriamente dito, no formato espercificado

WCS: Operações Suportadas



OGC: Web Coverage Service (WCS) - Prática

- Visualizar Layers criados
  - OpenLayers
  - GetCapabilities: http://localhost:8080/geoserver/wcs?request=getCapabilities
  - DescribeCoverage:

    http://localhost:8080/geoserver/wcs?request=DescribeCoverage&service=WCS&version=2.0.1&coverageId=aula__fusao_cbers
  - GetCoverage:

    http://localhost:8080/geoserver/wcs?request=GetCoverage&service=WCS&version=2.0.1&format=image/tiff&coverageId=aula__fusao_cbers
  - **Exercício: baixe o fusao_cbers com ¼ do tamanho original**

Web Processing Service

Catalog **S**ervice for **W**eb

JSON e GeoJSON

JSON (*Java **S**cript **O**bject **N**otation*)

- JSON é um formato de dados que ficou muito popular nas aplicações Web, principalmente entre as APIs de serviços RESTful:
  - Maior facilidade para leitura e escrita de um documento JSON;
  - As aplicações em JavaScript podem facilmente manipular dados neste formato.
  - Ex: Google Elevation API:

```
{
   "results" : [
      {   "elevation" : 18.1,
          "location" : {
              "lat" : 30.0,
              "lng" : -73.0
          },
          "resolution" : 76.0
   }],
   "status" : "OK"
}
```

JSON (Java Script Object Notation)

- Number:

  ```
  1234
  8.9
  ```

- String:

  ```
  "inside double quotes"
  ```

- Boolean:

  true ou *false*

- Array:

  ```
  ["Gilberto", "Ribeiro"]
  ```

- Object:

  ```
  {
      "name": "Gilberto",
      "age": 36,
      "country": "Brazil"
  }
  ```

GeoJSON

- GeoJSON é um formato de intercâmbio geoespacial baseado na notação JSON.

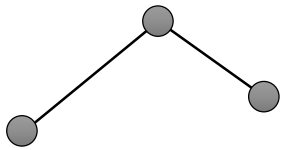
- Um objeto GeoJSON pode representar:
  - Geometrias
  - Feições
  - Coleções de Feições

GeoJSON: Geometrias

Point

```
{
    "type": "Point",
    "coordinates": [10.0, 10.0]
}
```

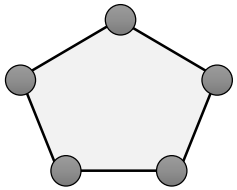
LineString



```
{
    "type": "LineString",
    "coordinates": [
        [10.0, 10.0],
        [20.0, 20.0],
        [30.0, 12.0]
    ]
}
```

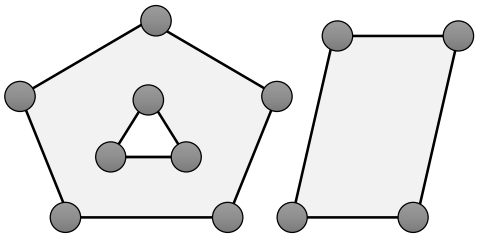
GeoJSON: Geometrias

Polygon



```
{
    "type": "Polygon",
    "coordinates": [
      [ [10.0, 10.0], ..., [10.0, 10.0] ]
    ]
}
```

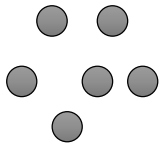
MultiPolygon



```
{
    "type": "MultiPolygon",
    "coordinates": [
        array-polygon1,
        ...,
        array-polygonn
    ]
}
```

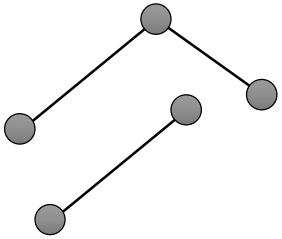
GeoJSON: Geometrias

MultiPoint



```
{
    "type": "MultiPoint",
    "coordinates": [
        [10.0, 10.0],
        [11.0, 11.0]
    ]
}
```

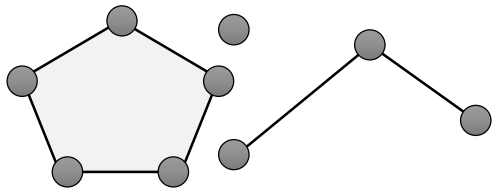
MultiLineString



```
{
    "type": "MultiLineString",
    "coordinates": [
        [[10.0, 10.0], [11.0, 11.0]],
        [[12.0, 12.0], [13.0, 13.0]]
    ]
}
```

GeoJSON: Geometrias

Geometry Collection



```
{
    "type": "GeometryCollection",
    "geometries": [
        {geom1},
        ...,
        {geomn}
    ]
}
```

GeoJSON: Feições

```
{
  "type": "Feature",
  "geometry":  {
      "type": "Point",
      "coordinates": [10.0, 10.0]
  },
  "properties": { "property-name": "value"}
}
```

GeoJSON: Coleção de Feições

```
{
    "type": "FeatureCollection",
    "features": [
        {
            "type": "Feature",
            "geometry":  {
                "type": "Point",
                "coordinates": [10.0, 10.0]
            },
            "properties": {
                "property-name": "value”
            }
        },
        ...
    ]
}
```

PostGIS: GeoJSON

- ST_GeomFromGeoJSON
- ST_AsGeoJSON

- Exemplo:

```
SELECT ST_ASGeoJSON(ST_Centroid(geom), 2, 3)
  FROM mg_municipios
```

bbox + CRS

2 casas decimais

A notação GeoJSON encontra-se em uso:

- Bibliotecas:
  - OpenLayers,
  - GDAL/OGR: GeoJSON Driver
  - MapFish
  - Mapbender
  - Programming languages: Java, PHP, Python, Ruby

- Servidores/Serviços:
  - GeoServer
  - MongoDB
  - Twitter
  - PostGIS

Source: http://wiki.geojson.org/Users

Validação JSON e GeoJSON

http://jsonlint.com/

http://geojsonlint.com/

STAC
(**S**patio**T**emporal **A**sset **C**atalog)

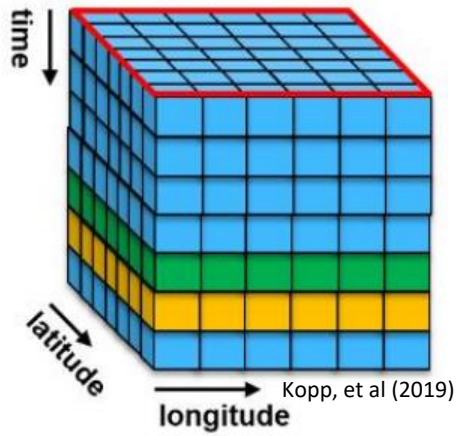
SpatioTemporal Asset Catalog

- Nova especificação em desenvolvimento:
  - Versão atual: 0.8.x
- Voltada para construção de catálogos de imagens de sensoriamento remoto (satélites, drones, aviões etc.).
- Objetivo de fornecer uma solução mais simples para catalogação de dados geoespaciais.
- Apoiada em padrões e tecnologiascomo:
  - JSON, GeoJSON, REST

STAC
SpatioTemporal
Asset Catalog

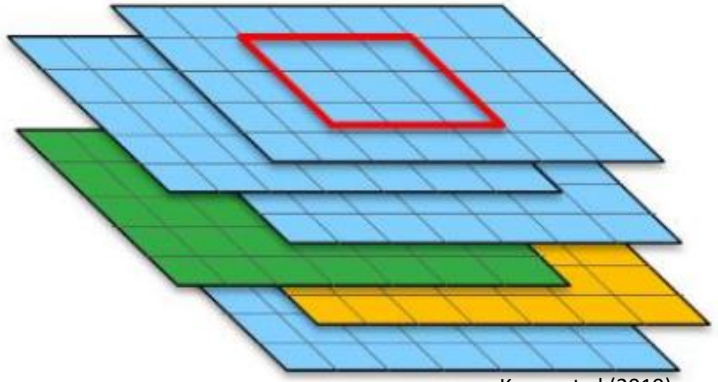
Assets

Collection



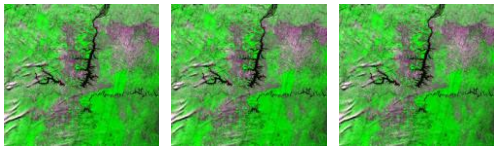
Kopp, et al (2019)

Collection



Kopp, et al (2019)

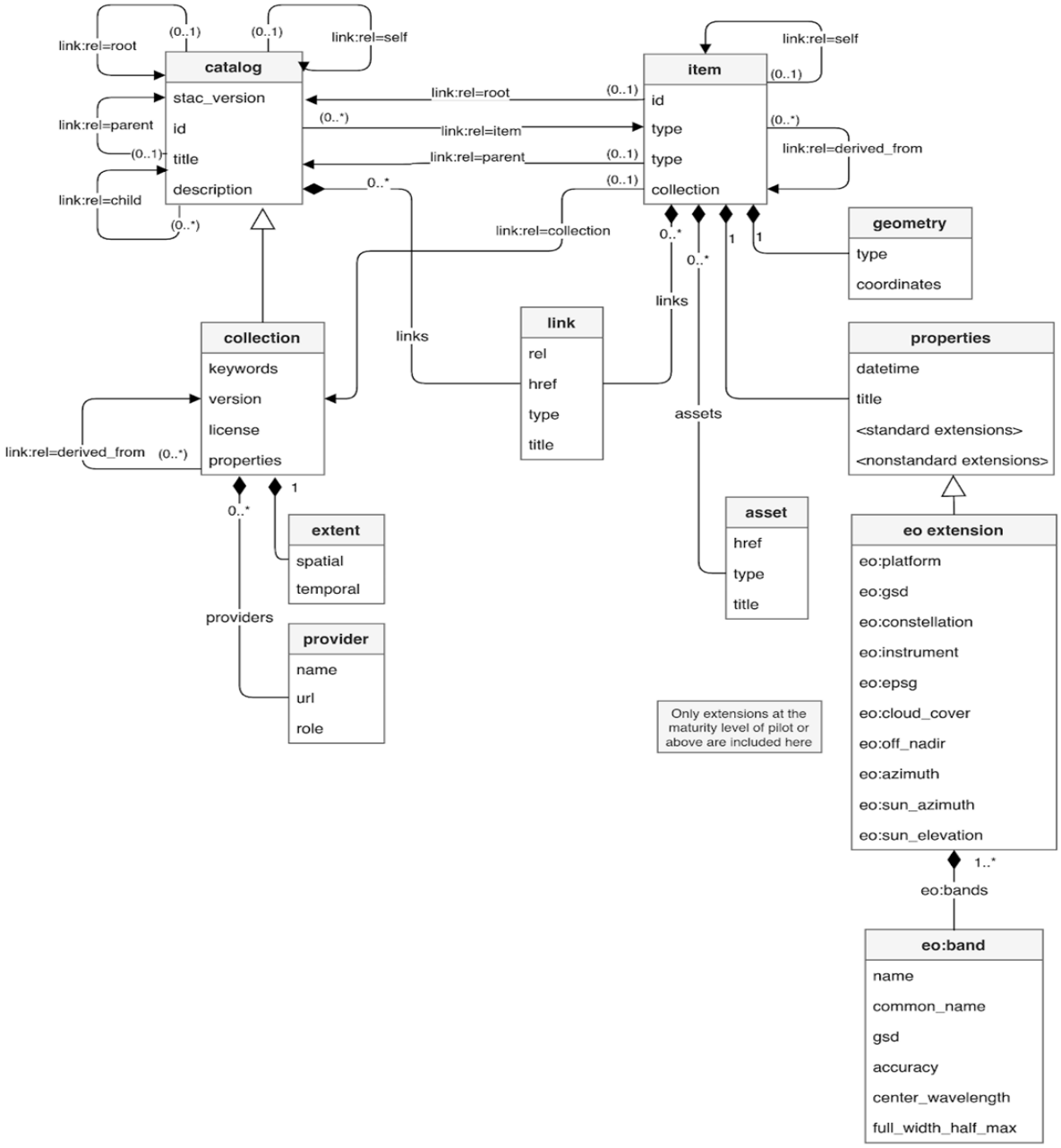
Assets



B1 B2

B3

STAC 0.7.0 Model



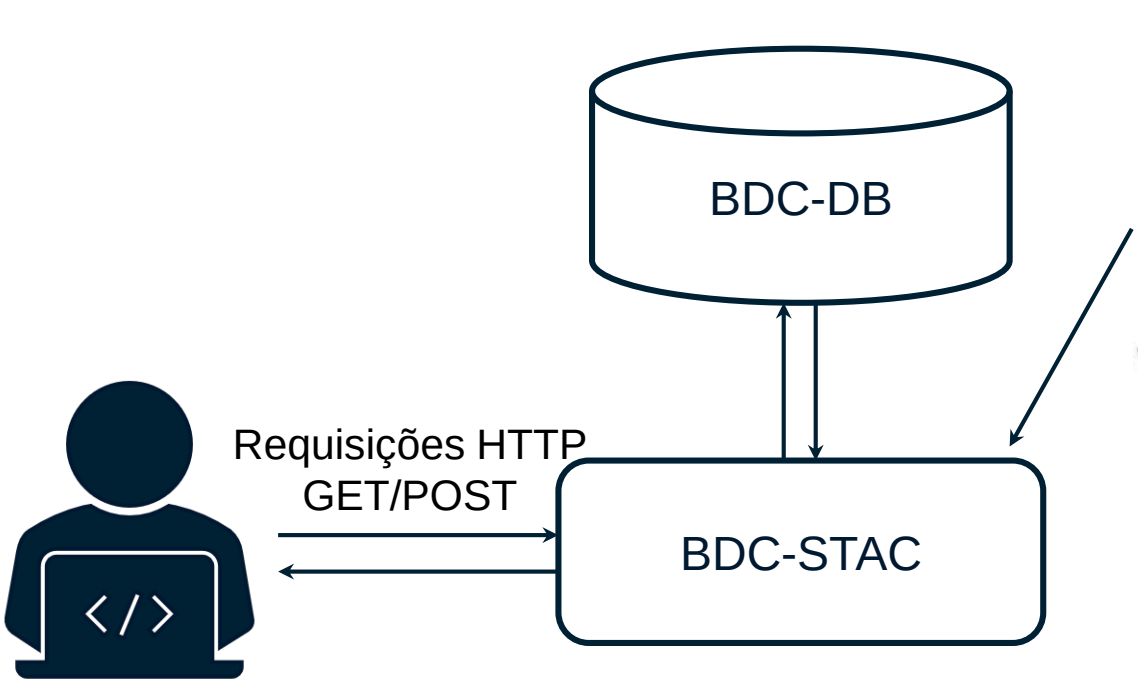
STAC API

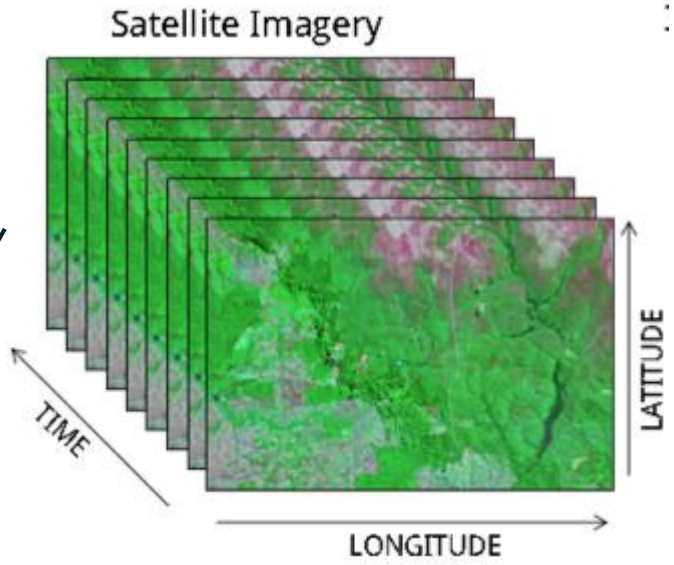
- Define uma API RESTFul para descoberta de dados em um catálogo STAC.

- Utiliza a iniciativa OpenAPI para descrição da API.

- Estende a especificação WFS 3 da OGC.
  - getCollections
  - describeCollections
  - getFeatures
  - getFeature
  - getSearchSTAC

Exemplo: Brazil Data Cube STAC





getCollections: /bdc-stac/0.7.0/collections

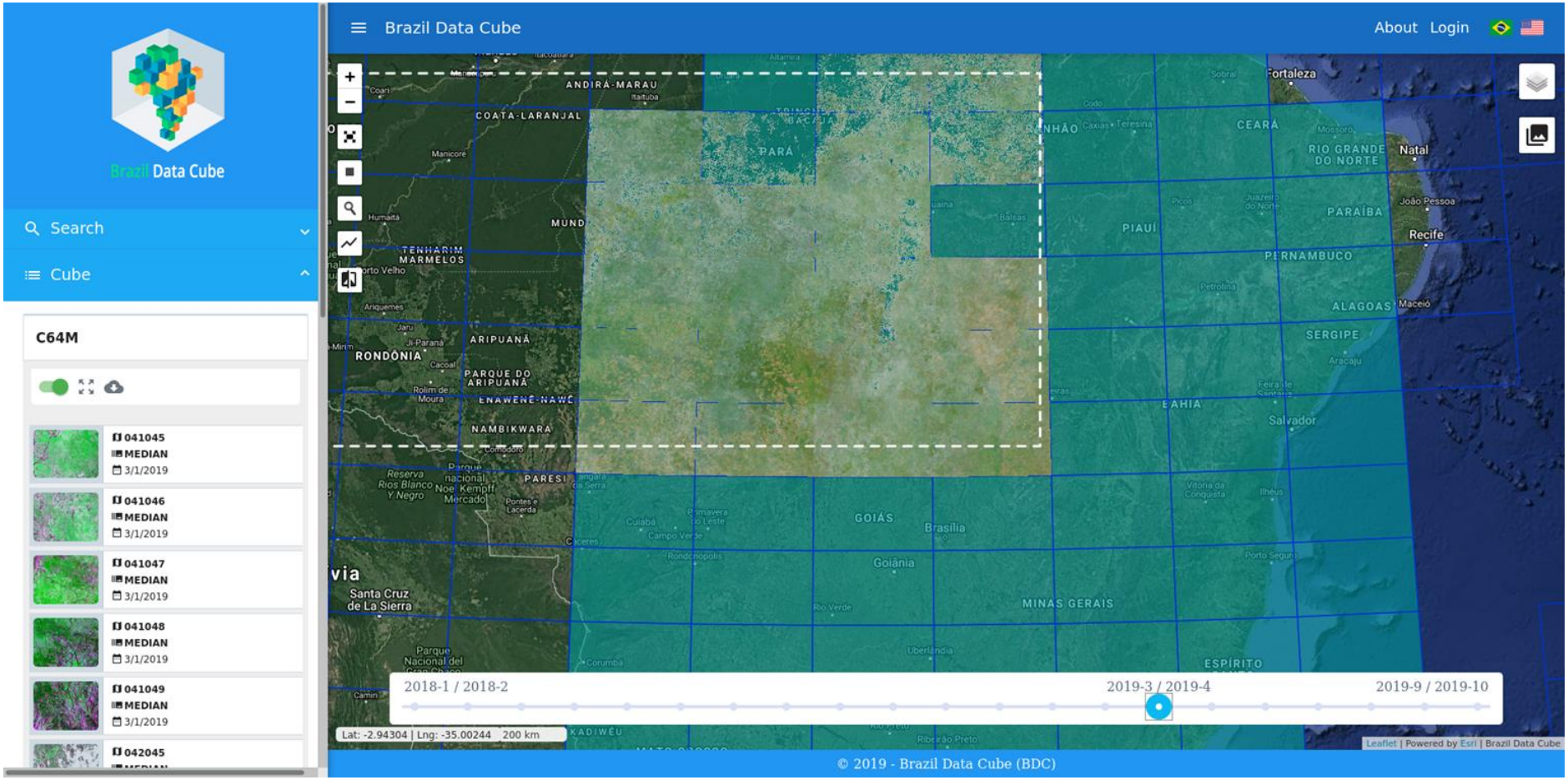
describeCollections: /bdc-stac/0.7.0/collections/C64mMEDIAN

getFeatures: /bdc-stac/0.7.0/collections/C64mMEDIAN/items

getFeature: /bdc-stac/0.7.0/collections/C64mMEDIAN/items/C64mMEDIAN-043049-2019-09-01-201

getSearchSTAC: /bdc-stac/0.7.0/stac/search

Exemplo: Brazil Data Cube Portal



Prática: STAC com Python

- Utilizar o Jupyter Notebook `stac.ipynb`

- Cliente STAC:
  https://github.com/brazil-data-cube/stac.py

WTSS
(Web Time Series Service)

TerraBrasilis

BDQueimadas

Portal Brazil Data Cube

Considerações Finais

Referências Bibliográficas

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Padrões e Especificações

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- OGC. ***Web Map Service***. Disponível em: <http://www.opengeospatial.org>. Acesso em: 17 abril 2012.

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