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ORIGINAL ARTICLE

GEOSPATIAL DATA SHARING SYSTEM: SisGEO

Sistema de Compartilhamento de Dados Geoespaciais: SisGEO

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Abstract
Geospatial data sharing, in the last decades, faced the inefficient, or even non-existent infrastructure of information technology. With the development and the popularization of new *hardware* and *software* components in personal computers, together with the investment on communication infrastructure, data traffic reached expressive increment. However, a lot of data that is produced by government institutions, research and data, is, to the present date, of difficult access to the society, and focusing on their availability, it was developed the Geospatial Data Sharing System, which aims to share geospatial data that had been produced by the course of Geography at the Federal University of Alfenas. The platform had been developed through the source code of *TerraBrasilis* platform, which had been developed by the National Institute of Space Research, which gently collaborated in the transfer of technology. The technologies that are used in this platform are based on open code *software*, and they follow the specifications of the *Open Geospatial Consortium*. After the phases of development and implementation, it was possible to make a WebGIS satisfactorily work, and making it public, free, geospatial data that will serve the society in the support of decision making.

Keywords: WebGIS, Geographical data, Open-source software, TerraBrasilis

Resumo
O compartilhamento de dados geoespaciais esbarrava, nas décadas passadas, na ineficiente ou até mesmo inexistente infraestrutura de tecnologia de informação. Com o desenvolvimento e a popularização de novos componentes de *hardware* e *software* em

computadores pessoais, aliados ao investimento na infraestrutura de comunicações, o tráfego de dados obteve um expressivo incremento. Entretanto, diversos dados produzidos por instituições de governo, pesquisa e ensino são de difícil acesso à sociedade até os dias atuais e, com o foco na disponibilização destes, foi desenvolvido o Sistema de Compartilhamento de Dados Geoespaciais, que objetiva compartilhar dados geoespaciais produzidos pelo curso de Geografia da Universidade Federal de Alfenas. A plataforma foi desenvolvida a partir do código-fonte da plataforma TerraBrasilis, desenvolvida pelo Instituto Nacional de Pesquisas Espaciais, que gentilmente colaborou na transferência de tecnologia. As tecnologias utilizadas nesta plataforma são baseadas em *softwares* de código aberto e seguem as especificações do *Open Geospatial Consortium*. Passadas as fases de desenvolvimento e implantação, foi possível dar funcionalidade a um WebGIS com desempenho satisfatório, tornando público, de forma gratuita, dados geoespaciais que servirão à sociedade no suporte à tomada de decisões.

Palavras-chave: WebGIS, Dados geográficos, Software de código aberto, TerraBrasilis

1. INTRODUCTION

The provision of free geospatial data to the public is a free task, because it can subsidize not only planning actions and land management, under many spatial clippings, but, as well, to promote the generation of information and gain of knowledge in geographical areas of interest.

The *software*, whose purpose is the storage, exhibition, manipulation and analysis of geospatial data, is commonly known as *Geographic Information System* (GIS) (BURROUGH; McDONNELL, 1998). The WebGIS (*Web Geographic Information Systems*) are tools that show interactive maps through web navigators that are broadly used in the data dissemination which, in turn, can be explored and analyzed by any person who has a computer with internet connection (SOUZA et al., 2005).

Xerox PARC Map Viewer (DAVIS, 1995), known as the first *WebGIS (now discontinued)*, aimed to provide interactive maps and features such as *zoom,* which allows the user to get the viewing closer or move it away, select the levels to be viewed, beyond being able to be accessed by a *web* navigator without the need of the installation of additional *software*, unlike *desktop* applications (FUU; SUN, 2010).

Open Geospatial Consortium (OGC) is characterized by being made by government agencies, research organizations and universities, aiming to standardize geospatial information, making them interoperable, reusable and accessible (OGC, 2020). Then, in order to allow higher interoperability, *open source* tools such as *Open Street Maps* and *Leaflet* (AGAFONKIN, 2018) make use of the international standards that had been set out by OGC, which show methods for the cataloging of metadata, storage and data transfer between different servers, and allow a dissemination of information for different users and institutions.

Open Street Maps is a project that freely provides geospatial data through a map that allows the use and modification of data. Its geospatial images can be downloaded and used in any project (COAST, 2015). The project also has a WebGIS in which its data is shown, and it is possible to hold operations like *zoom*, to change the theme and to export regions from the map.

In Brazil, the development of platforms for the provision of geospatial data has become frequent in State bodies in the most different governmental spheres, such as the Ministry of Environment (MMA), The National Institute for Colonization and Land Reform (INCRA), the National Water and Sanitation Agency (ANA), the Secretariat for Environment and Sustainable Development in the State of Minas Gerais (SEMAD), Institute of Water Management of Minas Gerais (IGAM), among others.

The application i3Geo (Integrated Interface for Internet of Geoprocessing Tools), is a Brazilian system that had been created by MMA and which is the national precursor in the area of interactive maps in the *web*, which allows the free dissemination of geospatial data, based on *open source* technologies (I3GEO, 2011), being used in many other bodies of governmental spheres.

TerraBrasilis is a platform which is characterized for being *WebGIS* that allows the viewing and geospatial data collection of environmental projects that had been developed by the National Institute of Space Research (INPE), through free *software* tools. This platform for the analysis of space data, uses concepts of micro services, and virtualization architecture for a better performance and ease of implementation (ASSIS et al., 2019).

In addition, the platform has the *software* tool *GeoNetwork*, with advanced functions of edition and search for metadata (TICHELER; HIELKEMA, 2007). It allows that a user who does not have any specific knowledge, has access to metadata through an Internet browser. Another important module of TerraBrasilis is an API (Application Programming Interface) which had been built to provide data collections, according to the paradigm of Data Science so that, later, data can be exploited in algorithms of machine learning.

Geospatial data can give support to decision making processes of public and private organizations, and, as well, can support planning actions, and management of watersheds, through committees and watershed agencies, according to what had been advocated by the National Policy of Water Resources, Law n. 9.433/1997 (BRASIL, 1997), beyond subsidizing other applications that demand georeferenced data.

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This way, the Research Group in Geodynamics of Watersheds (GeoHidro), a member of the Geography course at the Federal University of Alfenas (UNIFAL-MG), has developed projects in the scope of the watershed of Grande river, more specifically in the reservoir at Furnas Hydroelectric Power Plant and affluent watersheds, and because of the need of providing to the society geospatial data, there was started technical cooperation with the course of Computer Science at UNIFAL-MG, as well as with INPE, through the Processing Image Division (PDI).

In this context, the proposition of the customization of a *web* tool, through the source code of the platform TerraBrasilis (ASSIS et al., 2019), which had been denominated Geospatial Data Sharing System (SisGEO); it is characterized for being a *software* tool that aims to store, view and provide geospatial data in the web, which had been produced by members of GeoHidro and other partners.

2. SISGEO ARCHITECTURE

2.1. Development

SisGEO is the result of adaptations and implementation of new features in the source code of the *webmap* that arise from the platform TerraBrasilis (ASSIS et al., 2019). There were held changes in the inclusion of new features with the purpose of: (i) change the visual style of the website regarding SisGEO colors, texts and logos; (ii) remove some components that are not used at SisGEO, as the layers' color labels and the functionality of drawing polygons on the screen; and (iii) implement improvements on the sidebar of the graphic interface and visual style of the scroll bar: *slider* style of transparency for two decimal places after the comma, general fluidity in the vertical scroll when expanding layer groups that are called *visions.*

In the same application (*webmap*) there were developed new graphic interfaces of the user Graphical *User Interface* (GUI). An initial GUI that presents the SisGEO and other three GUIs, one for each project: "Mapping of Furnas lake", "Furnas Watershed" and "Furnas Topography". The prototypes of the GUI in these screens were elaborated through the tool *Figma* (WALLACE; FIELD, 2019).

Regarding the metadata, at TerraBrasilis they are shown by *GeoNetwork*. Then, TerraBrasilis *webmap* only has the URLs to access them. In the case of SisGEO, it was chosen to only show the metadata, without advanced functions for edition and search. Thereby, it was not necessary to use *GeoNetwork* and, instead, data is stored in the same database layer. Because of this, it was needed the amendment of the structure of the

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database and of the *business –api* module in order to support the new structure of metadata, creating a class to represent it in the code.

When the user accesses the SisGEO map, *webmap* requests to the *business-api* module, a list of layers that will be shown in the map, and their properties such as: layer identification; name; ID, URL description and prefix in the layer in the *GeoServer*, which belong to the entity named *data source*; *tool*, which is the available tool for a layer such as: metadata, *download*, transparency; URL for *download*. Some of these properties are the same between different layers and then, a lot of data that had been sent from the *business-api* to *webmap* are duplicate. At TerraBrasilis, it does not have great impact in the amount of sent data, once it shows 31 layers in the map. At SisGEO, where the map initially shows 148 layers, the duplicate data has significant impact in the size of the data that had been sent between *webmap* and *business-api.*

The property *datasource,* of the layers' data structure, represents a grouping of layers from *Geoserver*, and with this, layers from the same grouping had duplicate data, so that unnecessary data were sent from the *business-api* to the *webmap*. As the quantitative of layers is relatively expressive, regarding TerraBrasilis layers, with the perspective of an increase of SisGEO layers in the future, it had been identified the need to improve this aspect. Then, the way as these data are required by the webmap, returned by the business-*api* and treated by the *webmap,* were modified*.* As it can be seen on Table 1, *datasources* are now required in the function *searchforalldatasources*, while the visions are requested by the function *searchforallvisions.* Then, *datasources* are requested only once and one layer just has the *datasource* identifier, so that it can be correlated to it in the code, as it can be seen on line 7.

Table 1 – Algorithm passage with pseudocode to separately request *datasources* and *visions*

Line	Pseudocode passage
1	let visions = searchforAllVisions();
2	let datasources = searchforAllDatasources();
3	...
4	layersforEach((1layer) => {
5	…
6	const layer = newLayer(l.id);
7	layer. addDatasource (datasources. find (d => d.id == l. datasourceId));
8	…
9	layers. insert(layer);
10	});

Source: Authors, 2022.

Other layers' properties which were sent between *business-api* and *webmap,* are

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the *tools.* Each *tool* indicates which operation is available for the layer, such as: *download*, metadata, transparency and *zoom,* being that each layer can have more than one of them. Also, each *tool* shows properties such as: id, name, selector and *target*, being that the two last properties are related to the logic of the code and they do not need to be sent between business-*api* and *webmap*. In order that this data is not sent with a duplicate, the implementation of *business-api* was changed, so that only the tools' identifiers are sent together with each layer. The complete data for each *tool* were defined with a code and they are accessed through an identifier.

All the functionalities of SisGEO were verified through manual tests, by the development team, while the code was examined through visual inspection, in order to evaluate if the changes that had been done, are in accordance with the proposed standards by *Angular* technology, such as the components' standard, which specifies that a component is a reusable code unit, representing an element of the graphic interface, which facilitates the maintenance of the code (JAIN; BHANSALI; MEHTA, 2014).

2.2. Implementation

The geospatial images are served by Geoserver, a *software* that allows the edition and sharing of geospatial data (GEOSERVER, 2020). The *software Nginx* is a *web* server*,* which is integrated to SisGEO that acts as a *proxy* server, intercepting the requirements that had been made to Geoserver, to simplify and control the access to data (SYSOEV, 2019).

The module *webmap* is made by *Angular* and *Leaflet* technologies. *Angular* is a framework with functionalities that help in the development of *web* applications of single page (*web* pages that when receiving any action by the user, do not need that the page is reloaded), reuse of visual components, holding of tests, among others. *Leaflet* allows the display of geospatial data through *web* navigators (AGAFONKIN, 2018)*.*

To support the webmap module in the access to database, it was based in another TerraBrasilis module- *business-api-* which is an annex of *webmap.* The *business-api* uses the technology *spring boot*, which helps in the development of micro-services (SHARMA, 2016). *Business-api* fulfills the requirements, which come from the *webmap* module, on information of configurations that had been stored in databases. The *webmap* and the *business-api* as well, have open license code GNU 3.0 (STALLMAN, 2007), and their modifications and use are allowed, provided that the *software* that results from the adaptation, is under the same license.

To facilitate the implementation of SisGEO, not only locally but also in a production environment, the technology *Docker* was used. According to Garcia and Coin (2019), *Docker* uses the concept of *containers*, which are *software* units which group not only a desired *software* application, but also dependent *software.* Figure 1 shows the interaction between *containers* of the technologies used at SisGEO.

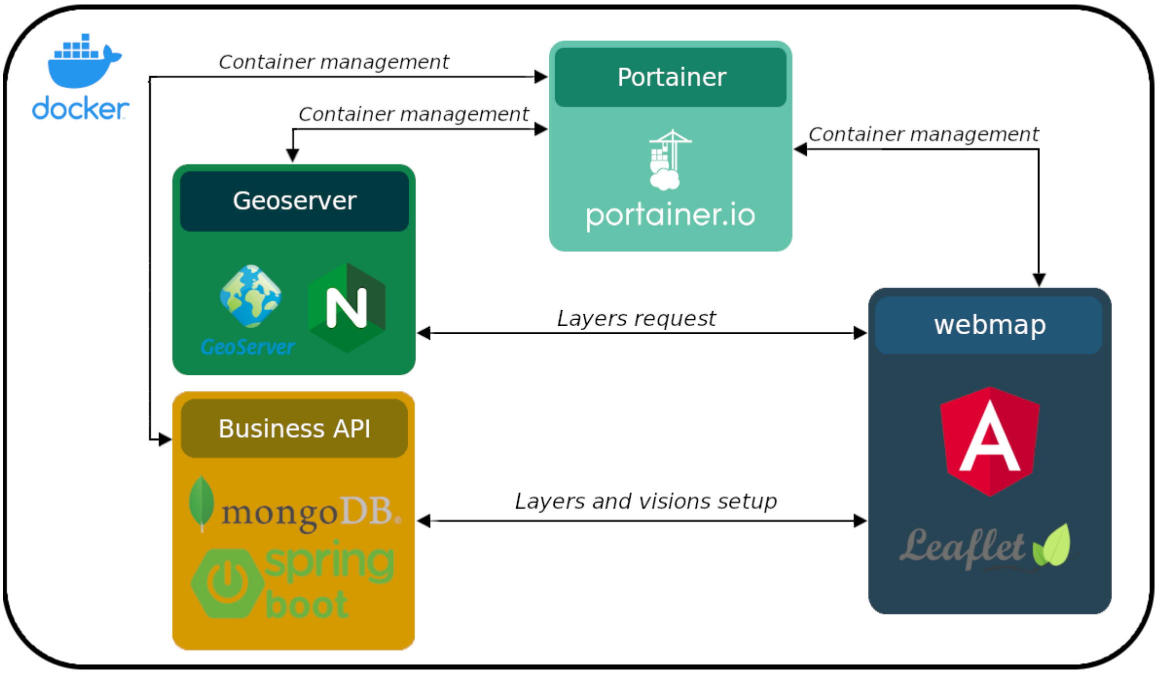

Figure 1 – Flowchart of the interaction between the *containers* of used technologies at SisGEO

Source: Authors, 2022.

For example, the *container* of the *business-api* project, has, beyond the code itself, which is needed for its execution, its annex code - *MongoDB* (MERRIMAN; HOROWITZ; RYAN, 2020), which is a technology of NoSQL database (non-relational) (LÓSCIO; OLIVEIRA; PONTES, 2011), based in documents that had been stored under the JSON format (*JavaScript Object Notation*). It was used a *container,* of Portainer technology, which had been proposed by Crosby, Alquist and Lapenna (2018), which allows the management of other *containers,* being that their management is done via a graphic interface in a *web* navigator.

When the user accesses the map at SisGEO, the module *webmap* receives this request and asks the *container* with the module *business-api*, for the data to be shown on the screen. This data has configuration information such as: the order in which the layers will be shown in the map, to which grouping each layer belongs to, the URLs (*Uniform Resource Locators*) for the *download* of the file in each layer and URLs of geospatial image.

The URLs show how to request layers to the container, with the Geoserver module. To the extent to which the user requests that a layer is shown on the screen, the *webmap*

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makes requirements to the Geoserver, which, in turn, returns the image of the requested layer. *Webmap,* when receiving a layer, processes this data with the help of *Leaflet*, which interacts with the Internet navigator so that the images can be shown.

There were inserted at Geoserver, the layers that had been developed by Campos and Latuf (2017), as well as the geospatial data of projects that had been done in the Laboratory of Cartography at UNIFAL-MG. The layers are made of: (i) mappings of Furnas lake, from the years of 1995-2019; (ii) pluviometric stations; (iii) main rivers; (iv) limit of Furnas watershed; (v) and, ultimately, 97 topographic maps at Furnas watershed. Some of this data is in the *Shapefile* format *(*ESRI, 1998) and others in Geotiff format (RITTER; RUTH, 1995). In the database there were inserted the URLs of the layers that are present in Geoserver, which are accessed by the application *webmap* and URLs for the download of the layers' files.

SisGEO was implemented in a dedicated virtual machine, in the server of the Center of Information Technology (NTI) at the Federal University of Alfenas (UNIFAL-MG), which can be accessed at https://sisgeo.unifal-mg.edu.br. SisGEO fulfills the requirements that use the protocol HTTPS (*Hyper Text Transfer Protocol Secure*), through the security certificate SSL (*Secure Socket Layer*), promoting the safety in the communication between the user and the SisGEO server.

2.3. Features

At SisGEO the layers are organized according to projects' topics, being that in each layer it is possible to: change the order of the layers' overlapping in the map; *download* the layer's file for viewing and manipulation through GIS *desktops;* view a table which contains the layer's metadata; change the transparency of the layer , through the *slider*, which helps in the comparison between layers (Figure 2); position the map in the desired layer in order to obtain information on the layer in the map, which are: area in square kilometers and *bounding box,* which are the four vertices (latitude and longitude) which surround the rectangle that involves the layer.

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Figure 2 - SisGEO Screenshot, highlighting functions and topics.
Source: Authors, 2022.

The general functionalities which are present in a map are: change the style of the background map; look for geographic coordinate; view latitude and longitude from any point of the map and *zoom*. In Figure 2, it is possible to view the list of available background maps, with options such as: *OSM*, *OSM Terrain*, *OSM Top*, which are styles of maps in the foundation *OpenStreetMap* (COAST, 2015) and also *Google Satellite*, *Google Streets*, *Google Hybrid, Google* map styles (GOOGLE MAPS, 2020).

After the implementation of SisGEO in a production environment, it was perceived a slowness in the initial uploading of the map, when holding operations in the layer, such as: enable, disable, change transparency, and when navigating through the map, when many layers were active at the same time.

The problem of slow navigation through the map, when many layers were simultaneously activated, mainly happened with layers of topographic maps (approximately 80 *megabytes*), significantly higher than the files of the layers of the water mirror of Furnas lake, with approximately 2 *megabytes*. In order to get around this problem, it was chosen to limit the system of activating in the map, more than 3 layers of topographic maps at the same time, being that in the rest of *visions*, the choice was to limit up to 10 simultaneous layers. This functionality was implemented with the possibility of customization, and it is possible to change these limits through commands in the database.

Through performance tests that were held in the phase of initial uploading of the map, it was viewed that loading all the visual components, of all the layers, was considerably deteriorating the performance of SisGEO. To solve this problem, it was implemented the

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functionality of the uploading under demand of the visual components, through the user's request.

Table 2 shows part of the implementation of this functionality, where there is the function *expandVision*, which is called when the user requests that a *vision* is expanded, listing their layers at GUI. The algorithm has the logic so that the list of layers is shown only if requested by the user.

Table 2 – Part of pseudocode with the algorithm of the functionality of under demand uploading

Part of pseudocode

```
expandVision (vision: Vision) {
        if (uploaded. Vision == false) {
              uploaded. Vision = true;
              render Layers ();
              addEventFromLayers ();
         }
   …
}
```

Source: Authors, 2022.

After these changes, the development team noticed significant and satisfactory improvements in the development of SisGEO, when accessed from computers of different configurations and navigators. SisGEO can be accessed from any device (mobile or *desktop*) with access to Internet.

3. FINAL CONSIDERATIONS

Through free *software* technologies and tools, it was possible to make it available to the society, geospatial data and metadata of the watershed from Furnas lake, free and through the Internet. This data can be accessed by any individual who has a computer with access to the Internet, through a *web* navigator.

With the implemented *software* structure, it is possible to have the feeding of geospatial data from many other projects, broadening the divulging of the findings of academic researches, and increasing their visibility. However, this activity is limited to people with knowledge on the NoSQL database and the use of technologies that require HTTP, such as Postman (ASTHANA; SOBTKI; KANE, 2020).

In this sense, the interdisciplinary cooperation between INPE, GeoHidro and the course of Computer Science at UNIFAL-MG will be kept, not only aiming the increase of geospatial data in the database, and the implementation of new functionalities in the system, but also aiming the formation of human resources with high technical competence in the areas of Cartography and Computing.

In order to have the continuation of the activities, efforts will be made for the implementation of a *web* graphic interface, or a *desktop* application, to facilitate the data insertion at SisGEO, as well as to look for improvements in the server that are related to the capacity of storage and memory for processing; the addition of functions of access to geospatial remote database, via WMS *(Web Map Service*), WFS (*Web Feature Service*) and WCS (*Web Coverage Service*) protocols; development of routine so that the user can elaborate a cartographic document via *WebGIS*; inclusion of functionalities in the change of layers' colors and subtitles; improve the cataloging and edition of metadata and, lastly, integrate, more fluidly, *rasters* data, enhancing the availability of clippings of satellite images and unmanned aerial vehicle, as well as digital models of upgrading.

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REFERENCES

AGAFONKIN, V. **Leaflet**. Versão 1.3.1[S.I.], 18 jan. 2018. Disponível em: <https://leafletjs.com/download.html>. Acesso em: 25 jul. 2020.

ASSIS, L. F. F. G.; FERREIRA, K. R.; VINHAS, L.; MAURANO, L.; ALMEIDA, C.; CARVALHO, A.; RODRIGUES, J.; MACIEL, A.; CAMARGO, C. TerraBrasilis: A Spatial Data Analytics Infrastructure for Large-Scale Thematic Mapping. **International Journal of Geo-Information,** Instituto Nacional de Pesquisas Espaciais - INPE, São José dos Campos, 26 de set. 2019. DOI: https://doi.org/10.3390/ijgi8110513.

ASTHANA, A.; SOBTKI, A.; KANE, A. **Postman: The Collaboration Platform for API Development**. Versão 7.24.0[S.I.], 31 jan. 2020. Disponível em: <https://www.postman.com/downloads/>. Acesso em: 28 jul. 2020.

BRASIL. Lei nº 9.433, de 08 de janeiro de 1997. Institui a Política Nacional de Recursos Hídricos. **Diário Oficial da União**, Brasília, DF, 09 jan. 1997. Art. 1º.

BURROUGH, P. A.; McDONNELL, R. A. **Principles of Geographical Information Systems**. Oxford: Oxford University Press, 1998. 333p.

CAMPOS, L. B.; LATUF, M. O. Base cartográfica digital da bacia hidrográfica do Lago de

ISSN 2318-2962
DOI 10.5752/p.2318-2962.2022v32n.69p.443

Furnas. In: PEREZ FILHO, A.; AMORIM, R. R. **Os desafios da geografia física na fronteira do conhecimento.** Campinas: Instituto de Geociências - Unicamp, 2017. p. 5732-5736. DOI: https://doi.org/10.20396/sbgfa.v1i2017.2275 .

COAST, S. **The Book of OSM**. CreateSpace Independent Publishing Platform, 2015.

CROSBY, M.; ALQUIST, K.; LAPENNA, A.; **Portainer: Simple management UI for Docker**. Versão 1.19.2[S.I.], 15 set. 2018. Disponível em: <https://github.com/portainer/portainer>. Acesso em: 20 jul. 2020.

DAVIS, P. **The Xerox PARC map server: an interactive hypermedia map viewer**. **Database** (Weston), v. 18, n. 2, p. 65-67, 1995.

ESRI (1998) **ESRI shapefile technical description.** Disponível em: <https://www.esri.com/library/whitepapers/pdfs/shapefile.pdf/>. Acesso em: 25 jul. 2020.

FUU, P.; SUN, J. **Web GIS:** Principles and Applications. Redlands (CA): ESRI Press, 2010.

GARCIA, W.; COIN, P. F.; **Docker - Containers não são VM's**. In: SEMINÁRIO DE TECNOLOGIA, GESTÃO E EDUCAÇÃO, 2019. Porto Alegre: Faculdade Alcides Maya, 2019. v. 1, n. 2, p. 5-10, 5 nov. 2019.

GEOSERVER. **GeoServer opensource**. Disponível em: <http://geoserver.org/>. Acesso em: 07 out. 2020.

GOOGLE MAPS. **Google**. Disponível em: <https://www.google.com.br/maps/>. Acesso em: 09 out. 2020.

I3GEO. **I3geo Documentação**. 2011. Disponível em: <http://mapas.mma.gov.br/i3geo/documentacao/>. Acesso em: 17 out. 2011.

JAIN, N.; BHANSALI, A.; MEHTA, D. AngularJS: A modern MVC framework in JavaScript. **Journal of Global Research in Computer Science**, v. 5, n. 12, p. 17-23, dez. 2014.

LÓSCIO, B. F.; OLIVEIRA, H. R. de; PONTES, J. C. de S. NoSQL no desenvolvimento de aplicações web colaborativas. In: VIII Simpósio Brasileiro de Sistemas Colaborativos, 2011, Paraty. **Anais...** Paraty: CESC (Comissão Especial de Sistemas Colaborativos), 2011. p. 1.

MERRIMAN, D.; HOROWITZ, E.; RYAN, K. **MongoDB.** Versão 4.2.3 [S.I.], 27 jan. 2020. Disponível em: <https://docs.mongodb.com/manual/tutorial/>. Acesso em: 16 ago. 2020.

OGC. Open Geospatial Consortium. **OGC Standards and Resources**. 2020. Disponível em: <https://www.ogc.org/standards>. Acesso em: 07 out. 2020.

RITTER, N.; RUTH, M. **GeoTIFF Format Specification GeoTIFF Revision 1.0.** 1995. Disponível em: <https://www.researchgate.net/profile/Joseph_Messina/publication/274079939_GeoTIFF_format_specification_GeoTIFF_revision_10/links/55c8fe9f08aea2d9bdc922b3/GeoTIFF-format-specification-GeoTIFF-revision-10.pdf/>. Acesso em: 25 jul. 2020.

SHARMA, S. **Mastering microservices with java**. Packet Publishing Limited, 2016. ISBN 9781785285172. Disponível em: <https://www.safaribooksonline.com/library/view/mastering-microservices-

with/9781785285172/>. Acesso em: 06 nov. 2020.

SOUZA, V. C. O.; OLIVEIRA, M. L. R.; VIEIRA, T. G. C.; ALVES, H. M. R. Portal Vertical GeoSolos - Spring Web na divulgação dos resultados de pesquisa em regiões cafeeiras de Minas Gerais. XII SIMPÓSIO BRASILEIRO DE SENSORIAMENTO REMOTO, 2005, Goiânia. **Anais...** Goiânia: INPE (Ed.), 2005. p. 2389-2396.

STALLMAN, R. 2007. **The GNU Operating System and the Free Software Movement**. Disponível em: <https://www.gnu.org/licenses/gpl-3.0.en.html>. Acesso em: 11 jul. 2020.

SYSOEV, I. **Nginx**. Versão 1.15.3 [S.I.], 21 jan. 2019. Disponível em: <http://nginx.org/en/download.html>. Acesso em: 11 ago. 2020.

TICHELER, J.; HIELKEMA, J. U. Geonetwork opensource: Internationally Standardized Distributed Spatial Information Management. **OSGeo Journal**, v. 2, p. 1, 2007.

WALLACE, E.; FIELD, D. **Figma**. Versão 76.4.0 [S.I.], 28 out. 2019. Disponível em: <https://www.figma.com/downloads/>. Acesso em: 22 ago. 2020.

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