

## **Simbology for Small Scale Reference Mapping: Automation and Sharing of Symbols**

**Flávia Silveira<sup>1</sup>, Gabriele Silveira Camara<sup>1</sup>, Silvana Philippi Camboim<sup>1</sup>**

<sup>1</sup>Programa de Pós Graduação em Ciências Geodésicas – Universidade Federal do Paraná (UFPR)

Caixa Postal 19.001 – 81.531-980 – Curitiba – PR – Brazil

Flaviasilveira.silveira@gmail.com, camaragabriele@gmail.com,  
silvanacamboim@gmail.com

***Abstract.** This work presents the stages to develop solutions to automatized the standardized simbolization of features represented in topographic maps at small scales in the Brazilian context, as well to perform the storage and sharing of symbols. The automation of the process was possible through the development of a plugin within the QGIS open source geoprocessing software environment, using Python programming language, and the storage and sharing of the symbols was done through the Github platform, which has version and free distribution and open source.*

### **1. Introduction**

According to the Brazilian Institute of Geography and Statistics (in Portuguese, Instituto Brasileiro de Geografia e Estatística - IBGE), the reference mapping aims to represent the territorial space in a systematic way, through series of topographic maps with the characteristic of being continuous, homogeneous and articulated. According to the Brazilian legislation [BRASIL 1967], it is executed by the Federal Government through the Coordination of Geographic Services (in Portuguese, Diretoria de Serviço Geográfico - DSG) and the IBGE for standard scales of 1: 1,000,000, 1: 250,000, 1: 100,000, 1: 50,000 and 1: 25,000.

The symbology is the set of definitions which determines the cartographic language used by the reference mapping for representing its features, considering the scale of the data representation and its level of generalization. These variables are related to the elements of color, level of detail and size of the cartographic symbols, in addition the specifications related to labels (font, size, and others). In the development of the reference mapping, it is necessary to be aware of the graphical presentation of the information contained in the map, because it is through the cartographic symbols that the communication of this information to the user happen [Keates 1973].

According to Sluter et al (2016), the standard cartographic symbology is an important feature for any reference mapping aiming to share information produced by different sources.

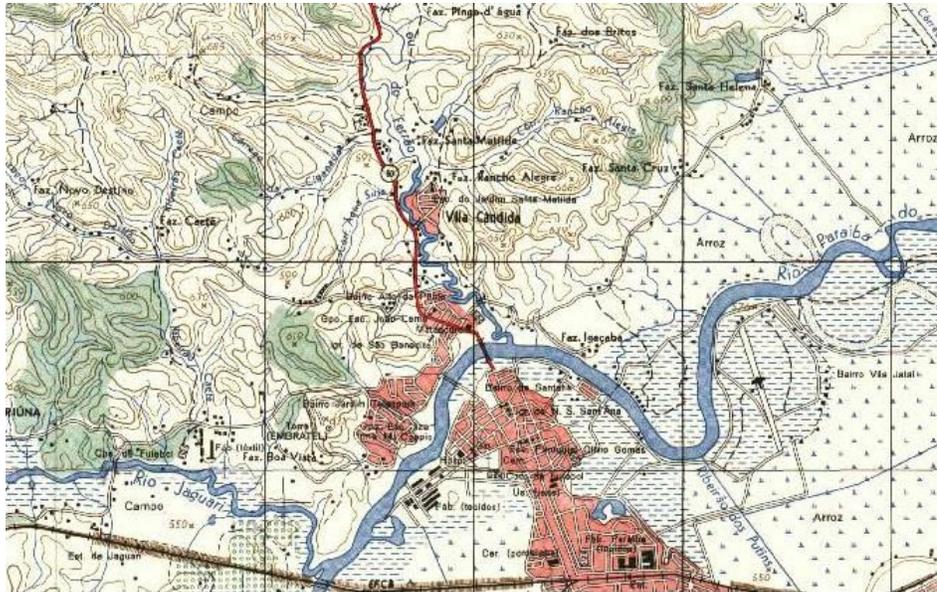
Until the present moment, in the Brazilian context, the symbology is only standardized for the cartographic representation in small scales (scales 1: 25,000 and smaller) defined by Technical Manual T34-700 - Cartographic Conventions (in Portuguese, Manual Técnico T34-700 - Convenções Cartográficas), shown in figure 1. The manual was developed by the DSG and has two parts, the first that establishes the

norms for the representation of the natural and artificial features for small scales, and the second that specifies the characteristics of the standardized symbols for the use in topographic maps.

N°	SISTEMA DE TRANSPORTE	AQUISIÇÃO DE DADOS		REPRESENTAÇÃO GEOMÉTRICA	REPRESENTAÇÃO FINAL		T 34-700 (1ª PARTE)
		Símbolo	Especificações		Símbolo	Especificações	
100	Trilha ou picada		SSNR - 1,50 mm	Linha		0,13 - 	CAPITULO 2 - PARÁGRAFO 2 - 2 - LETRA a - PARÁGRAFO 2 - 3 - LETRA a - ITEM 1) - PARÁGRAFO 2 - 4 - LETRAS a, c, d, e, g, i, j
101	Caminho carroçável		SSNR - 1,50 mm	Linha		0,20 - 	CAPITULO 2 - PARÁGRAFO 2 - 2 - LETRA a - PARÁGRAFO 2 - 3 - LETRA a - ITEM 2) - PARÁGRAFO 2 - 4 - LETRA a, c, d, e, f, g, i, l, n, e, q
102	Rodovia de tráfego periódico		SSNR - 1,50 mm	Linha		0,13 - 	CAPITULO 2 - PARÁGRAFO 2 - 2 - LETRA a - PARÁGRAFO 2 - 3 - LETRA a - ITEM 3) - PARÁGRAFO 2 - 4 - LETRAS b, c, d, l, n, o, e, p

**Figure 1. A part of Technical Manual T34-700 - Cartographic Conventions**

The figure 2 shows a part of the São José dos Campos map symbolized according to the T34-700 manual.



**Figure 2. A part of the São José dos Campos map**

The application of the symbology defined by the technical manual is a constant need for companies and institutions that develop cartographic materials supported on basemaps, especially digital products, such as interactive maps. Some symbols defined for the cartographic features representation are complex, therefore, the work of assigning the proposed symbology becomes a time-consuming work. Currently, there are only a few known tools to optimize or automate this process, and even fewer open source solutions.

The storage and sharing of symbols is also a latent demand, the symbology can be defined and stored in several formats and shared in different ways. The SLD (Styled

Layer Descriptor) established by the Open Geospatial Consortium (OGC) to represent the layers and their labels in WMS, by editing an Extensible Markup Language (XML) file. QML Layer Style File (QML) is also an important format because it is used by the open QGIS platform. So, the challenge is to store the symbols to facilitate their application and sharing in an open platform, then they can be accessed by the largest number of users, helping to ensure the standard in the symbolization of topographic maps.

The open source initiative, started in the 1990s [OSI 2018], provides a collaborative improvement in software, such as QGIS, and in open data platforms such as Open Street Map. However, when we talk about symbology, there is no open platform using user collaboration. Thus, the development of a collaborative system for symbology, with the user as an actor in the process of elaborating and sharing symbols, is important for management, improvement and propagation of the open data for cartographic representation.

This work aims to present the project and the steps for the development of a plugin for the open platform QGIS, which allows the automatic application of the symbology defined by the technical manual T34-700 for elements represented in small scales, as well as present the solution found to storage and sharing of digital symbols.

## **2. Symbology Description Formats and Sharing**

The characteristics of the cartographic symbols can be stored in the tabular form as it happen in the Brazilian context, through the Technical Manual T34-700, as well as in the digital format, through symbol storage files, which are text files that describe the symbol properties such as graphic primitive, color, size, border thickness, and label characteristics. The most popular storage formats of symbology features and labels are: Styled Layer Descriptor (.sld), QGIS Layer Style File (.qml) and ESRI Layerfile (.lyr).

The OGC (Open Geospatial Consortium) created, in 1999, the Web Map Service (WMS), a web service that distributes matrixed tiles that are already symbolized using the SLD symbology pattern. The SLD format can be understood as a WMS profile, that together with the Symbology Encoding (SE) specification, allows the user to configure how the data will be displayed. The SE language is an XML language (Extensible Markup Language), which describes coding rules that defines symbol styles.

Currently, there is a worldwide trend to share geospatial data to facilitate the access to information of public interest, but the sharing of cartographic symbols in digital format is not yet widespread. In the international context, entities like Ordnance Survey, the British mapping agency, use platforms such as Github to share sld, qml and lyr symbology formats.

Github is the interface of the free distribution system and open source, Git, used to store and share codes [Github 2018]. In Github, the files are organized into repositories, defined by folders referring to projects created by users, which can be public or private, and repositories can belong to individual accounts or organizations.

The cartographic symbols are text files, so, they can also be shared via github to be accessed by the largest number of users and contribute to the standardization of the cartographic representation of the reference mapping.

In the Brazilian context, the only work that is known about symbol sharing is Fernandes (2012), where the author proposed a library of sld symbols, which would be available on the INDE portal, in order to facilitate the process of standardizing of topographic mapping symbology, helping the INDE to realize one of its fundamental components: data interoperability.

### **3. Materials and Method**

#### **3.1. Defining User Needs and Features**

For the geospatial application development, the objectives were delimited based on the User Centered Design concepts, which, according to Abras *et al.* (2014) is defined as processes that end users influence the development of an application.

The plugin architecture was developed to show the structure of the application, According to Bass *et al.* (2003), the software architecture is understood as a generic standard for a project, explaining the solutions development to meet the needs of the project. The main plugin functionalities are connect to a database and offer options of symbols and scales to represent the features to the user's map.

#### **3.2. Creation of Database and Symbology Files**

The geospatial database was created on the PostgreSQL using the rules established by Technique Specification to Geospatial Vector Data (in Portuguese Especificação Técnica para Estrutura de Dados Geoespaciais Vetoriais - ET-EDGV), fundamental assumption for the plugin operation. The ET-EDGV provide a standard geographic vector data in small scales (1:25,000 or smaller) in order to guarantee the interoperability between data originated from different sources. This Technique Specification was produced by National Spatial Data Infrastructure (in Portuguese Infraestrutura Nacional de Dados Espaciais - INDE), conceived in 2009 through Brazilian Federal Decree n° 6.666, with the goal to provide generation, storage, access, sharing, dissemination and use of geospatial data of federal, state, district and municipal origin.

In the database were entered the data referring to the classes Localities, Hydrography and Transport of the reference mapping of the Unit of the Federation of Rio de Janeiro in the scale of 1: 25,000.

Afterward, was developed on the QGIS the symbols standardized for the features of these three classes from the T34-700 Technical Manual. The symbols were saved in a QGIS Layer Style File format (.qml).

#### **3.3. Plugin Implementation**

The QGIS's plugin was developed using the programming language Python, the cartographic data was stored in PostGIS, which is a PostgreSQL extension, object-relational database system. The interface was designed in the QtDesigner software.

To develop the plugin it was also necessary to use the Plugin Builder complement, this QGIS's complement provides a basic model that helps to create plugins for this software. The file generated by Plugin Builder has Python extension and

allows editing, so, the plugin is able to accomplish the tasks programmed by the user [GEOAPT LLC 2017].

The libraries used for the plugin development were:

- PyQGIS: Python library to develop QGIS's applications. This library allows to create custom plugins based on the QGIS Application Programming Interface (API) [QGIS 2017].
- Psycopg2: library that allows the communication between Python and PostgreSQL. This library enables the execution of SQL commands in the Python language, as well as allowing access to many resources offered by PostgreSQL [PSYCOPG 2017].

The experimental data used to the plugin development were the classes Localities, Hydrography and Transport referring to the Continuous Rio de Janeiro Cartographic Base, in 1: 25,000 scale. This data are available by the Brazilian Institute of Geography and Statistics (IBGE) at its electronic address ([www.ibge.gov.br](http://www.ibge.gov.br)).

### **3.4. Storage and Sharing via GitHub Implementation**

Initially, in order to centralize the information and projects related to the symbology study, an email account was created ([opencartographicstyles@gmail.com](mailto:opencartographicstyles@gmail.com)), this e-mail was also used to register the github account.

Associated with the github user was created an organization called Open Cartographic Styles, initially, containing a repository referring to the symbols, `mappingGrandeEscala`, and another related to the symbology plugins, `pluginsSimbologia`.

In the `mapeamentoGrandeEscala` repository, the files format chosen to the sharing were SLD (Styled Layer Descriptor) and QML (QGIS Layer Style File), compatible with the Geoserver and QGIS software, respectively. To ensure the files interoperability and standardization, they were organized according to the classes established by ET-EDGV and each file was named according to the nomenclature of the category.

## **4. Results**

### **4.1. System Architecture**

The architecture developed for the application (Figure 3), presents the system operation, in order to understand that the shapefile format files stored in the database are loaded through the interaction between the QGIS and the developed plugin. The predefined symbols are used by the plugin to be applied in the selected layers, and those layers are represented with the desired symbology.

The predefined symbols are stored on github, where the user can download the files to their computer and allocate them in a folder, which can be referenced in the plugin and than applied to the layers stored on the database or in another projects in the QGIS.

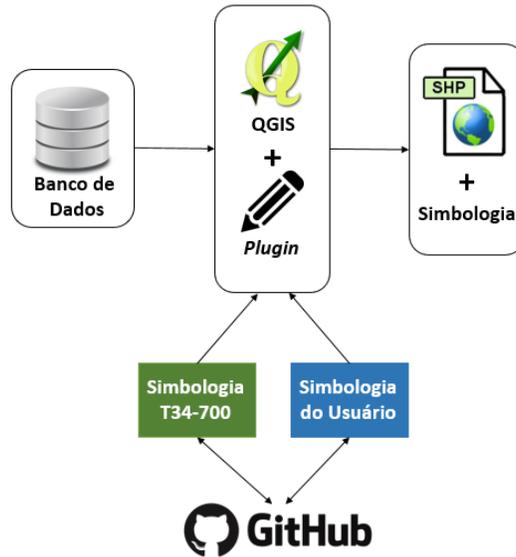


Figure 3. System architecture

#### 4.2. Interface and Plugin Functions

The developed plugin interface (Figure 4), presents the application resources, listed and described below.

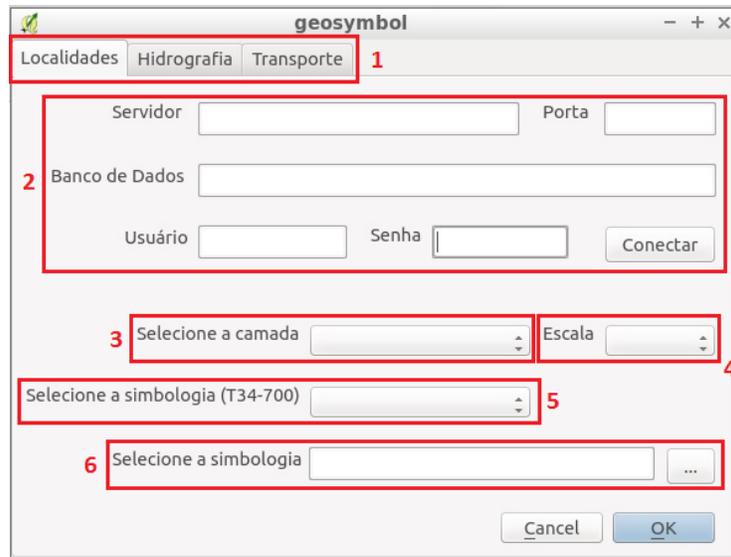
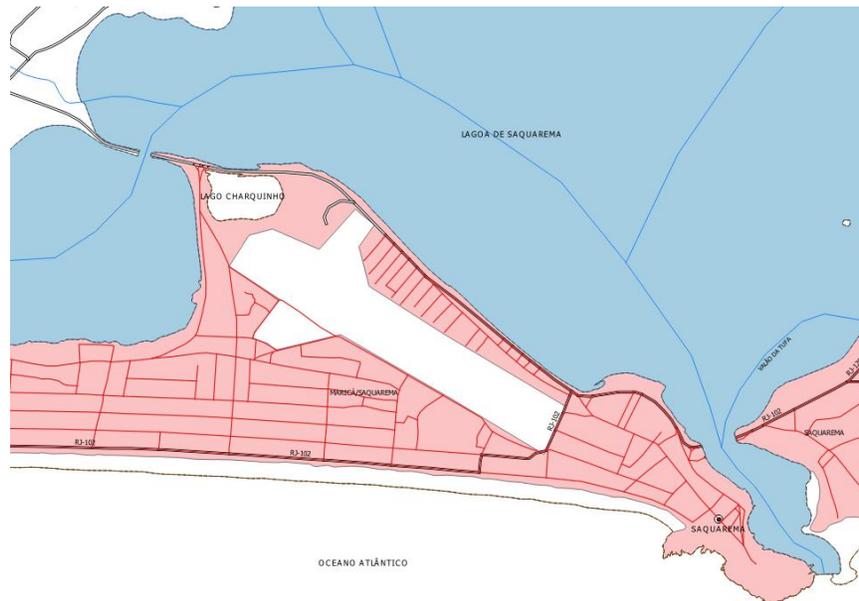


Figure 4. Plugin interface

1. To develop the plugin, three standardized classes by Technical Manual T34-700 were used (localities, hydrography and transport). Each class is represented by a tab in the plugin interface, and the user can choose one of them to work.
2. After choosing the class, it is necessary connect to the database, informing the server, port, database name, user name and password.

3. When the database is already connected, the user can chose on a combo box the layer to be symbolized. Only layers belonging to the selected tab group can be chosen in the combo box.
4. It is possible to select on a combo box the data display scale. The possibilities are the scales defined for the Brazilian systematic mapping: 1: 25,000, 1: 50,000, 1: 100,000, 1: 250,000 and 1: 1,000,000.
5. Then, it is possible to select the symbology to be applied to the previously selected layer through a combo box that presents the standard symbologies defined by the T34-700. The symbologies presented in the combobox are related to the selected layer graphic primitive, it means, if the layer selected in step 3 is represented by the point graphical primitive, only symbologies for point features can be selected in step 5, the same logic is applied to the line and polygon graphic primitives.
6. Another way to select the desired symbology is through a "button box", with it, the user is able to select ".qml" symbology file of his computer, and it will be applied to the previously selected layer.

The figure 5 shows the symbology proposed by the Technical Manual T34-700, applied automatically in scale 1:25,000 to the Hydrography, Localities and Transportation classes to a region of the state of Rio de Janeiro by the plugin developed.

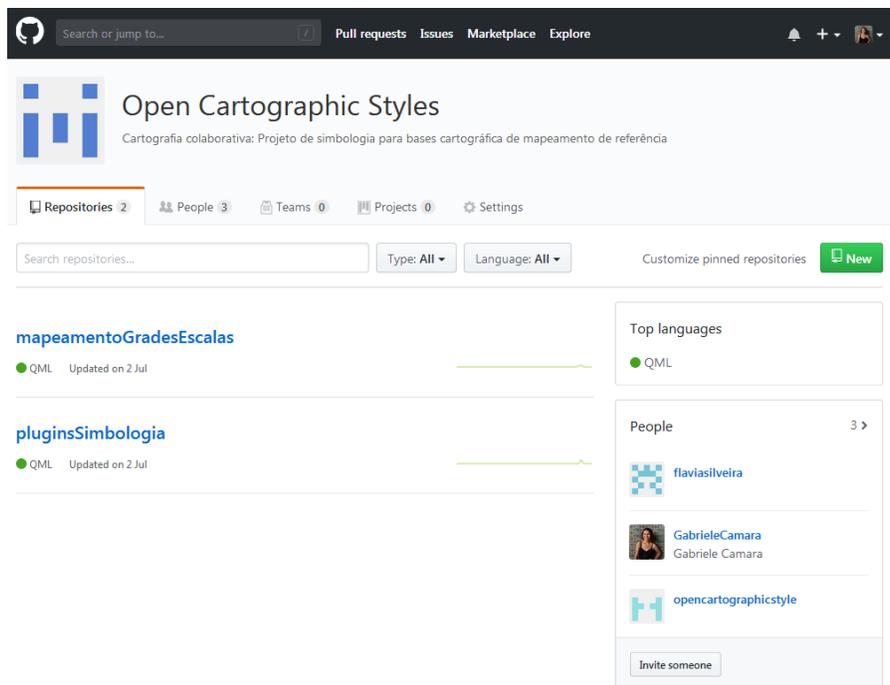


**Figure 5. A part of the state of Rio de Janeiro symbolized according Technical Manual T34-700 by the plugin developed.**

The benefits of the developed plugin are ensure a correct application of the symbology for small scales, data interoperability between different sources of cartographic datas and provide to a common user a tool to apply a appropriate scale according to the symbology.

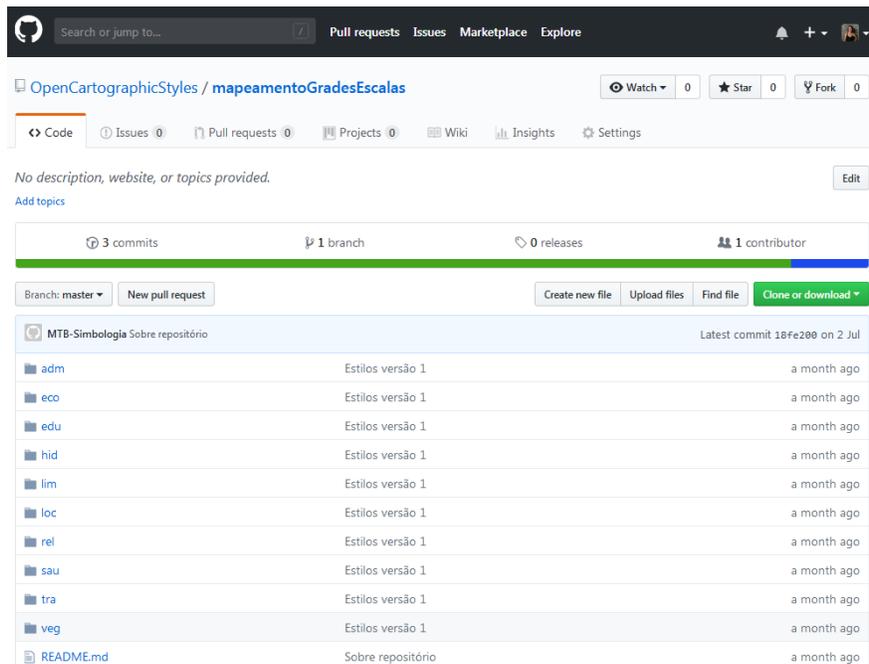
### 4.3. Github

The initial page of Open Cartographic Styles github organization, made to storage and sharing the symbology of reference mapping and other application related (Figure 6), presents the repository related to the symbols, mapeamentoGrandesEscalas, and another associated to the plugins, pluginsSimbologia. The plugin's repository contains applications developed in python so far elaborated by symbology research group, intended for use in QGIS.



**Figure 6. Initial page of github**

Within the symbology repository (Figure 7) 10 classes of symbols were stored and shared. Seven of those classes are: Administration (adm), Education (edu), Economic Structure (eco), Limits (lim), (rel), Health Structure (sau) and Vegetation (veg). The other 3 classes, included in the plugin described in this article, are: Localities (loc), Hydrography (hid) and Transportation System (tra), according to ET-EDGV.



**Figure 7. The repository mapeamentoGradesEscalas related to the symbols**

According to the nomenclature of the files as the ET-EDGV categories, there is a pattern, beginning with the name of the class, followed by the name of the feature, and finally, a code according to the graphic primitive.

## 5. Conclusion

The standard symbology is indispensable for any mapping, especially for the reference mapping, because the symbols quality ensures the cartographic information understanding, and consequently its recognition and decoding, an essential process for cartographic communication.

However, symbology standardization, in the case of Manual T34-700 for small-scale representations, it is not in accordance with the Brazilian standard ET-EDGV established by INDE. Therefore, the interoperability of data from the reference mapping is impaired, making difficult using and sharing those symbols. For this reason, it is necessary to update these symbology standards according to ET-EDGV, for small and large scales, ensuring the sharing and interoperability of data from different source.

The use of the free software QGIS and its functionalities allowed the creation of the plugin and the possibility to distribute and share it openly in the future, helping the symbology implementation process. Likewise, the use of Github ensures that the symbols storage and sharing are also open and collaborative processes. Either solutions assume the user as a collaborator, and the central figure of the process, since the user is consumer and symbology producer.

The issues of automatization of the basemaps symbolization process, storage and sharing of cartographic symbols are not yet widely discussed in the Brazilian context. Future studies on these subjects can benefit and take the present work as a basis.

In the Free Geospatial Laboratory of the Federal University of Paraná, researches are also being developed related to the symbolization of reference mapping in large scales and symbology through vector tiles.

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