Publishing Old Maps as Dynamic Map Services

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Abstract. This paper summarizes various resources of old maps which are published in digital format on the Internet in the area of today's Czech Republic. The most important old maps providers are either Czech universities, state authorities or research institutions. A list of significant old maps and their providers on the Internet has been created and is accessible online at http://gisserver.fsv.cvut.cz/stare_mapy/ (in Czech).
The arguably most important old maps have been published using a map server as dynamic map services (including WMS and KML according to OGC standards). Metadata of the map services are bilingual Czech and English). A web map application with these services is accessible at http://gisserver.fsv.cvut.cz/old_maps/.

Keywords: Old Map, Map Service, History, ArcGIS Viewer for Flex

1. Introduction

The quality of maps has always been an important part of the maturity of the state. Maps were used for military purposes, for toll collection on important roads, for land-tax collection, etc.

The problem with old maps published online is that they are in a form of image-view only applications such as Zoomify, and no overlay with contemporary maps is possible. Therefore, of authors from the Department of Mapping and Cartography at the Czech Technical University in Prague decided to process selected old maps and publish them as dynamic map services and to present them in a form of a web mapping application.

This contribution then focuses on the creation of a public web mapping application containing four significant old maps, which serve as a case study for future investigations. Old maps are published there in form of raster and/or partially vectorized datasets. These map services are also involved in the public web mapping application.

2. The History of Selected Old Maps of Bohemia

At first, various resources of old maps which are published in digital form on the Internet in the area of today's Czech Republic were reviewed and summarized. The most important old maps providers of old maps are Czech national universities, state authorities or research institutions. A simple list of important old maps and their online providers has been created and is accessible at http://gisserver.fsv.cvut.cz/stare_mapy/ (only in Czech at present).

The focus of this paper is on four arguably most important old maps of Bohemia (historical land representing western and central part of today's Czech Republic). These maps are: Klaudyan's map dated 1518, Criginger's map 1568, Aretin's map 1619 and Müller's map 1721. These four maps serve then as a case study for publishing old maps online using a map server.

2.1. Klaudyan's Map of Bohemia

The oldest map of the area of today's Czech Republic is the Klaudyan's map of Bohemia dated 1518. Master Nicholas Klaudyan was the creator of the first printed map of this territory. The map was published in Nuremberg, because Czech printing workshops did not have necessary equipment.

The map does not have any title and the author is remarked "Mikulass Klaudian. Letha Bozieho Tisycziho pietisteho Sedmnaczteho". The whole work is 1 260 mm long and 640 mm wide, but only the lower third of this area presents a map with dimensions of 450 × 550 mm. The map scale is approximately 1 : 637 000. A salient feature of the Klaudyan's map is its southern orientation.

This map is very important from cartographic perspective as well as from historical perspective, because it evaluates images of social statuses of the early 16th century in its figurative part. For example, the Czech and Hungarian King Louis the Jagiellonian is displayed with emblems of countries in which he ruled. Below this king an allegory of Justice is depicted**,** followed by heraldic decoration (see fig. 1).

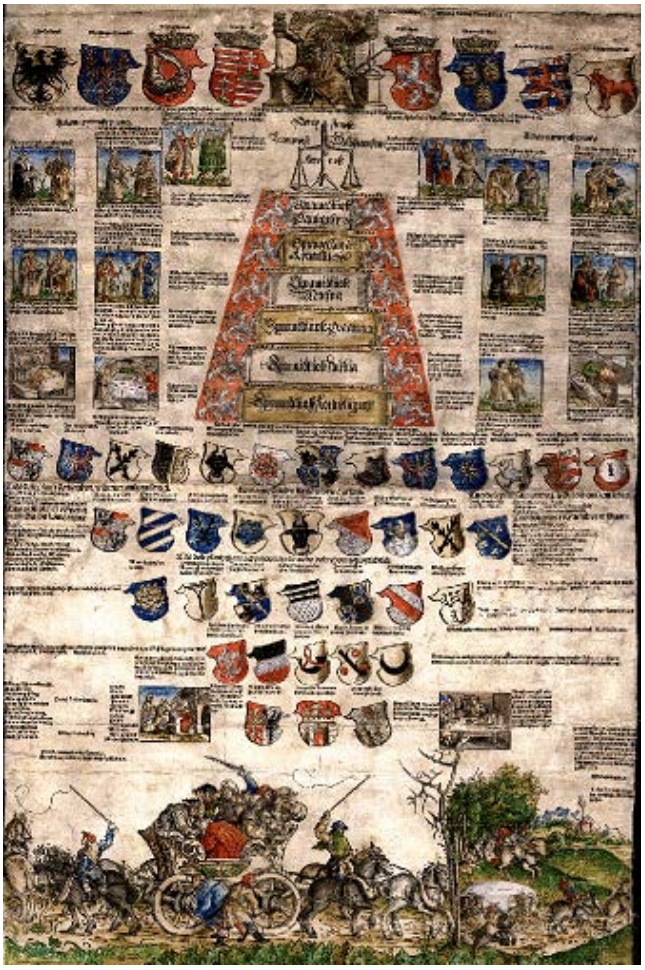

Figure 1. Decoration of Klaudyan's map of Bohemia.

Klaudyan's map contains altogether 280 municipalities, distinguishing 37 royal cities symbolized by a crown and 53 noble towns symbolized by a shield. Noble towns are further divided by religion – catholic or protestant cities. Other types of symbols represent municipalities and other settlements such as castles, monasteries and fortresses. Between the cities, red dots are placed, that represent milestones (mile distances are most likely in the Czech miles, one Czech mile equals approx. 9.25 km). Also paths, mountains, forests and rivers are schematically drawn. Orography is marked by repeating the symbol of vegetation. Only significant water flows are labeled (Vltava, Labe, Ohre and Jizera rivers).

Apart from copies from the 16th century, some excellent copies from the 19th century created by James Francis Henry Kreibich prevailed. The origi-

nal of Klaudyan's map is preserved only in a single copy that is stored in the Episcopal Library in Litomerice.

2.2. Criginger's Map of Bohemia

Criginger's map of Bohemia, titled "Bohemiae regni chorographica descriptio" was published in 1568. Johann Criginger was a famous cartographer. His two cartographic works, the Criginger's map of Bohemia and map of Saxony and Thuringia are both included in the atlas "Theatrum orbis terrarum" of Antwerp cartographer Abraham Ortelius.

Criginger's map of Bohemia is more extensive than Klaudyan's map, even though Criginger drew it at home, without traveling around Bohemia.

The size of the entire engraving is 510 × 340 mm. The map area has an oval shape with dimensions of the main axes of 486 mm and 412 mm. Cartographic analyses provided the approximate map scale 1 : 683 500. The oval is in the east and west supplemented with semi-circles. The remaining area in all four corners is filled with engravings which depict several male figures and the emblems of Bohemia, Moravia, Silesia, Upper and Lower Lusatia. At the top of the ornamental frame the emperor Rudolf II in a small circular medallion is displayed (see fig. 2).

Figure 2. Decoration of Criginger's map of Bohemia

Criginger's map contains a very successful record of Czech mountains and water flows symbolized by hills and trees. Altogether, there are 292 municipalities which are divided into four types.

The best known copies of this map were published by Munster and Ortelius. Less known copies of this map, which supplemented geographic names in southern Bohemia, were published by de Jode and Mercator. One copy of the map is stored in the library in Salzburg. Second copy was found in the Strahov Library in Prague. Both prints are incomplete.

2.3. Aretin's Map of Bohemia

Aretin's map of Bohemia was published in 1619. Its author's name was Paul Aretin. He was the only publisher of this third complete map of Bohemia. The map was created on the basis of actual measurements which were probably the result of measurements of the surveyor Simon Podolsky. The map was published in two editions during Aretin's life under the title "Regni Bohemiae nova et exacta descriptio". The first edition was printed using copper plates with dimensions of 766 × 574 mm. The map scale was estimated according to the mile frame approx. 1 : 504 000. Along the right and left margins there are six characters in contemporary costumes.

The second edition experienced important changes. The most noticeable change is the updated view of water flows in eastern Bohemia. The map had most certainly been used for military operations, as can be deduced from displaying troops near Hradec Kralove and Pardubice.

In subsequent editions of Daniel Vusin and his son Kaspar the positions of water flows were refined and forests were drawn into the map in southern Bohemia. In all editions of this map there is an image of the Czech lion and the imperial eagle in the two upper corners. These two figures with the remark "cum consensu superiorum" served as an official "stamp" in this map.

Sixteen symbols distinguish between free royal cities, stately homes, monasteries, mines, glassworks and spas. Beside these, locations of findings of the most precious stones are also recorded. Orographical and hydrographical drawings are, compared to Criginger's map, at better level, especially in terms of labels. On the other hand the road network is missing in this map.

Aretin's map is the first map in which the boundaries of political division of the country (15 regions) appeared. An index is attached, which contains 1 157 places sorted alphabetically; each place has two rectangular coordinates in the Czech miles mentioned. At the end of the index there is an important cartometric information about the perimeter and the area of former Bohemia.

2.4. Müller's Map of Bohemia

Müller's map of Bohemia is one of the most important maps published in the Czech lands. It is the largest map in the world issued by single individual (Johann Christoph Müller).

The full name of the map is "Mapa geographica regni Bohemiae in duodecim circulos divisae cum comitatu Glacensi et districtu Egerano adiunctis circumiacentium regionum partibus conterminis ex accurata totius regni perlustratione et geometrica dimensione omnibus, ut par est, numeris absoluta et ad usum commodum nec non omnia et singula distinctius cogno-

spenda XXV sectionibus exhibita a Joh. Christoph Müller, S.C.M. capitan. et ingen A.C. MDCCXX".

The holy Roman emperor Charles VI issued in 1712 a note, by which Müller was obliged to create a map of Bohemia. The main reason for creating the new map was a better toll control on roads and mapping all municipalities.

Johann Christoph Müller mapped Bohemian regions from 1712 until 1718. During the summer, he performed field measurements. He determined the geographical coordinates of significant municipalities astronomically from the stars. The distances between major municipalities he measured also using compass and a measurement car. He processed the measured data during the winter. Throughout the whole territory he mapped all settlements, mines, water flows, roads and administrative boundaries. Also the altimetry is displayed in the map by the symbol of hills.

After issuing maps of regions he began working on connecting all the map sheets into one. He created a map work consisting of twenty-five map sheets with dimensions 2 822 × 2 403 mm. In the lower left corner a large legend is situated, the title is in the lower right corner. Furthermore, all four corners are filled with drawings of motives from Bohemia. The approximate scale of the map is 1 : 132 000.

In 1720, the map was almost completed and Müller began to perform last corrections. Unfortunately his health did not allow him to finish correcting the entire map. Müller's map of Bohemia was published in 1722, one year after the author's death.

3. Raster Georeferencing and Vectorization

3.1. Klaudyan's Map of Bohemia

The vector model of Klaudyan's map of Bohemia was created within a master thesis at the Dept. of Mapping and Cartography in 2007 [5]. The author created a complete vector model, which consists of five shapefiles. Three of them are point shapefiles – towns, vanished towns and castles. The remaining two are line shapefiles – rivers and roads.

Raster maps as well as vector models were transformed into the national S-JTSK coordinate system using six identical points – towns: Prague, Trutnov, Decin, Ostrov, Klatovy and Chotebor. The data has been transformed using affine transformation with the standard deviation of transformation 10.5 km.

3.2. Criginger's Map of Bohemia

Vector model of Criginger's map of Bohemia comes from the student work of 2008 [4]. A complete vector model was created, consisting of five shapefiles. Three are point shapefiles – towns, vanished towns and castles. One line shapefile represents rivers. One polygon shapefile contains borders.

Raster map as well as vector model were transformed into the S-JTSK coordinate system, based on ten identical points: Prague, Ceske Budejovice, Plzen, Karlovy Vary, Louny, Litomerice, Turnov, Trutnov, Pardubice and Hradec Kralove. The data has been transformed using affine transformation; the standard deviation of transformation was 11 km.

3.3. Fabricius's Map of Bohemia

The map was scanned and georeferenced within the master thesis defended in 2006 [1]. Vector model of this map is not yet available.

3.4. Müller's Map of Bohemia

All the works on the creation of a vector model and georeferencing of Müller's map of Bohemia were carried out under the grant project GACR 205/09/P102 "Comprehensive study, analysis and disclosure of Müller's map of Bohemia and Moravia using GIS technology". The complete vector model consists of eleven shapefiles. Four are point shapefiles: municipalities, bridges, road nodes and water nodes. Three are line shapefiles: administrative boundaries, roads and water flows. Four are polygon shapefiles: municipalities, water areas, administrative boundary of Bohemia and administrative boundaries of regions.

The map was transformed on the basis of 4 627 identical points (current and former municipalities). The standard deviation of affine transformation was 2 400 m.

4. Publishing Old Maps as Dynamic Map Services

4.1. Geodatabase

The old maps were scanned at high resolution, as displayed for each map in table 1 below. Raster files were stored in tiff format.

	Resolution [pixel]	Size [MB]
Klaudyan	3691 x8091	86
Criginger	7825 x5702	128
Aretin	12110 x10345	494
Müller	25208 x 22338	1570

Table 1. Parameters of digital maps

Raster and vector datasets have been imported into one file geodatabase. The total size of the whole geodatabase is about 2GB.

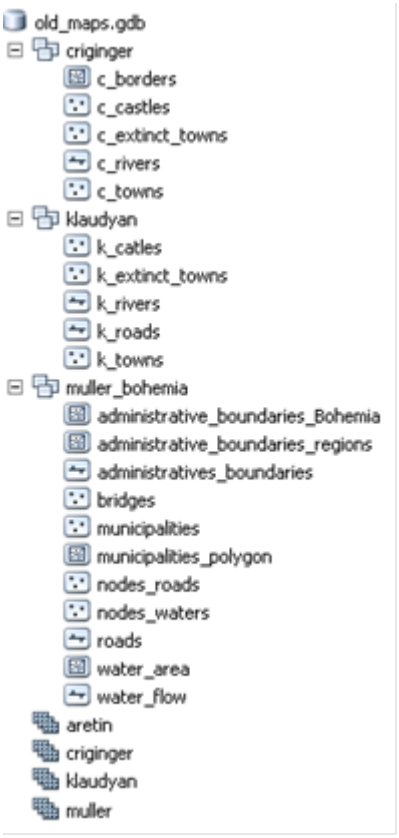

Figure 3. File Geodatabase Structure

4.2. Map Server

There are various solutions in the field of map servers, including commercial (Esri, Intergraph) as well as open source (GeoServer, UMN MapServer) platforms. At the CTU there is a campus license of ArcGIS products available, therefore the ArcGIS Server 10.1 technology has been selected as the main mapping platform.

The basic function of ArcGIS Server is to provide GIS services, primarily map services. Map services are the basic means of sharing spatial information in the form of map image. Thanks to defined interfaces (such as REST or SOAP) the services might be consumed by various applications;

they give the ArcGIS services the form and look. ArcGIS Server supports well-known standards such as WMS, WFS, WCS and KML.

The REST interface of ArcGIS services can be accessed at URL: *http://<server name>/<instance name>/rest/services*. For displaying information about published services of the old maps see: http://gisserver.fsv.cvut.cz/arcgis/rest/services/old_map/.

ArcGIS map services are published simultaneously as WMS (WMTS), WFS and KML services according to OGC standards. WMS services are accessible at *http://gisserver.fsv.cvut.cz/rest/arcgis/services/old_map/<service_name>/MapServer/WMSServer*.

Map services include bilingual metadata in Czech and English. All map services have been added to the gallery at arcgis.com (ArcGIS Online) portal at http://www.arcgis.com/home/search.html?q=Map%20of%20Bohemia&t=content.

4.3. Map Application

Interactive map browsing is enabled to the end user through a web map application. ArcGIS Viewer for Flex was selected due to its interactivity and simplicity. ArcGIS Viewer for Flex is configured in XML. The application is independent of the web server operating system as well as independent of the web browser, because it runs in a sandbox using Adobe Flex technology. The only requirement is therefore the Adobe Flash Player plug-in installed within the end-user's browser.

For faster response and map displaying, raster map services have been cached using the tile same tiling scheme as ArcGIS online basemaps to be able to use ArcGIS online maps. The map cache itself of four raster services takes about 1 GB of disk space.

The application's URL is http://gisserver.fsv.cvut.cz/old_maps/, a screenshot is on fig. 4 below.

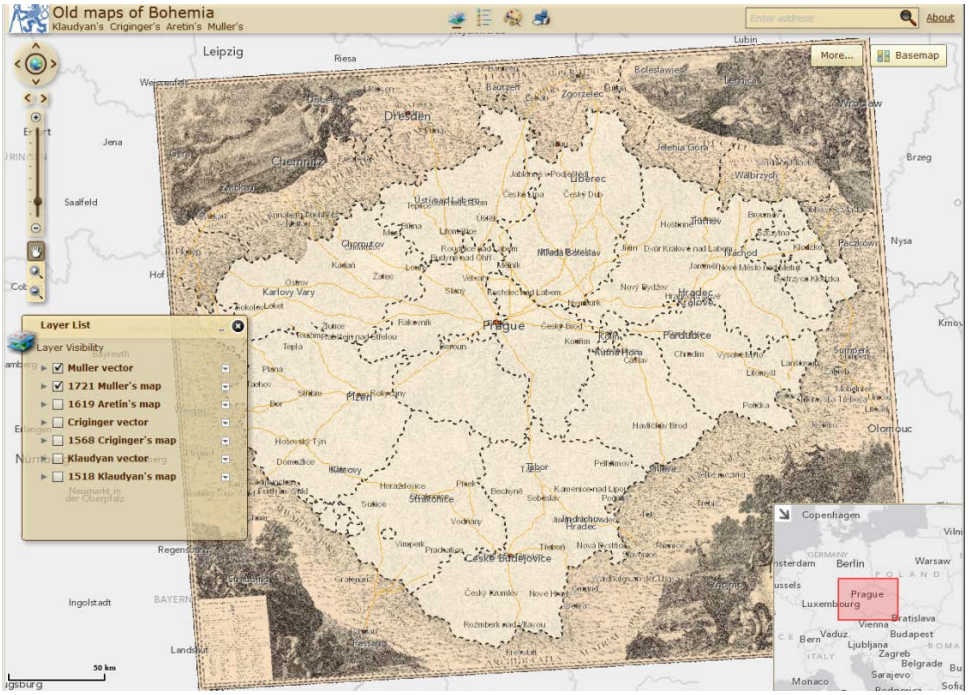

Figure 4. Web Map Application

5. Conclusion

Using the GIS software of Esri (ArcMap, ArcGIS Server 10.1 and ArcGIS Viewer for Flex), selected old maps have been published as dynamic map services including WMS, WMTS, WFS and KML. A web map application based on ArcGIS Viewer for Flex has been created, which is available at http://gisserver.fsv.cvut.cz/old_maps/. Because of large volumes of raster data the map services containing rasters have been cached, which enables very fast loading of data into the web map application.

5.1. Future Plans

It is planned to continue publishing the old maps and to include them in the web map application (e.g. the Müller's map of Moravia). A scrollbar controlling the visibility of layers according to time will be programmed into the Flex application.

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