

## Semantic Model of Digital Resources of Bulgarian Bells

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In an attempt to meet the need for presentation and preservation of the Bulgarian cultural heritage of Bulgarian bells, a team from the Institute of Mathematics and Informatics, with Humanitarian specialists has developed a multimedia digital archive called BellKnow. It was designed to provide digital data for a representation of acquired knowledge. The information collected and a used technology in the digital storage allow development of virtual exhibitions. At this paper we will present our work on construction of network semantic connections between specialized data and with this we began our building of an ontological system of Bulgarian bells. Also, our solution allows to build a virtual representation of objects on the Internet. Addition of semantics to virtual exhibitions will allow the data have collected to become a shared knowledge of Bulgarian bells worldwide.

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### 1 Introduction

At present, Bulgaria is in a new stage of its culture and spiritual progress. Conditions for researching our common heritage and for new preservation methods development are more favorable now that Bulgaria joined the European Union. Church bells are one of the most important parts of our cultural heritage. As a historical object the bell has general properties such as geometric dimensions, weight, etc. and one very specific property – its sound. That is why we create an archive that contains records of the sound of each of the bells, acoustical diagrams, videos and images obtained using contemporary equipment. Collection of information is done by different specialists (engineers, mathematicians, computer scientists, historians, accredited bells assessors, etc.) [6]. For this operation are passed many sites using the following special equipment:

- Audio recording – specialized audio equipment;
- The photo and video equipment – specialized HD cameras SONY;
- Measurement of dimensions - laser meter, digital meter, etc.

The aim of the Knowledge - Fund "BellKnow" is to do research and identification of valuable bells located in churches and monasteries and create an archive using modern technologies for analysis, storage and protection of audio information. We develop semantic web and ontology system of unique Bulgarian bells. We also consider the problem of authorship authentication and signing of RDF graphs. We use these results to create RDF graphs signing procedure and apply it to the ontology system of unique Bulgarian bells [2].

## 2 Digital multimedia archive - BellKnow

Considering that there is a digital archive for unique Bulgarian bells, and there is lot of interesting information hidden in digital resources, we make an intelligent annotation of knowledge. A digital archive is developed by using advanced technologies for analysis, reservation and data protection, and it contains [1, 3, 5, 7]:

- The main bells' characteristics: design, form, type, geometric size, decorative and artistic scheme, weight, material, state, characteristics of chime, data about the producer and owner of the bell, estimation of its historical value;
- Digital photos and video recordings of the bells while being tolled;
- The frequency spectrum of the bells during a stroke;
- The bells' frequency spectrum after transitive process;
- Charts representing the sound fade by time, sound stream, sound pressure and other acoustic characteristics.

The multimedia archive of BellKnow contains:

Digital data:

- More than 3 000 digital records with added digital steganographic sign (invisible watermark);
- Including photo pictures, video clips, audio records;
- Technical data, historical references, passports, diagrams etc.

Each digital resource contains:

- Digital files format, parameters, coding;
- Specific signature for file name.
- Additional META textual data for indexing of media files:
  - Title (name of subject);

- Creator (name of digitalizer);
- Description (additional data);
- Date (date of creation);
- Type (type of media);
- Format (file format, codec and parameters);
- Identifier (geographic coordinates);
- Rights (owner of property rights).

In establishing the digital archive we should keep in mind that it has a tree file structure where all objects are arranged. FotoStation program allows an archive to a multitude of primary and sub directories. The program has built in powerful file editor providing all functions needed for working with files located on a computer system.

### 3 Documentation and passportization

First steps of the project “BellKnow” was to develop an archive containing detailed description of church bells, as well as to develop a digital archive (using advanced technologies) for analysis, reservation and data protection. To accomplish this we have to document the main bells’ characteristics: design, form, type, geometric size, decorative and artistic scheme, weight, material, state, characteristics of chime, data about the producer and owner of the bell, estimation of its historical value. So, in case that unexpected circumstances destroy a bell, the archive will keep the specific details to be investigated by different specialists. This requires:

- To document the main features of the bells: type, geometric size, decorative and artistic design, weight, material, condition, features in the sound, the manufacturing and owner assessment of historical value;
- To make basic scheme of bells position;
- To present digital photographs of the bells and videos during their beat;
- To analyze and record the frequency spectrum of the bells at the moment of impact;
- To analyze and record the frequency spectrum of the bells in the established prime etc.

Based on these and other data we prepare a passport model for each test bells. This passport could be used to document the future of all existing bells in Bulgaria. Passports are summaries of all the information gathered about an object, in this case several sets of bells in one place. This includes photographs, historical reference, technical data, charts and research done in the electronic version



Figure 1: Passport bells in a historical place.

of the passport – embedded multimedia files with recorded audio and video clips. This passportization is a publication of all data collected from various studies in a document. The document includes sections in which information is divided into:

- Home page of the document and location of the bells;
- Page with a presentation of the draft study and identification of church bells in Bulgaria;
- History of the location of the bells (monastery, church, museum, etc.);
- Scheme of the bells of a given place;
- For each bell following data is included:
  - Picture materials;
  - Technical data shown in the next scheme (dimensions, location, type, material, year and place of creation, creator, etc.);
- – Art Design of the bell (historical data, captions, pictures, decorations, ornaments, etc.);
  - Data from sound analysis, supported by diagrams;
  - Digital recording - video clips and sound recordings.

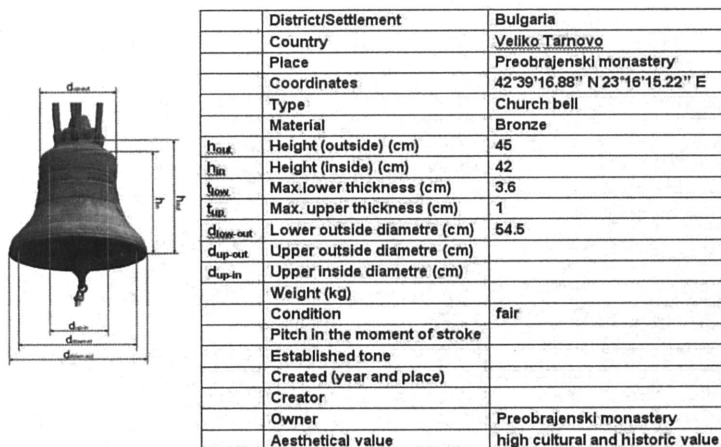


Figure 2: Scheme of the bell and technical data. Bell number one in Preobrajenski monastery, near Veliko Tarnovo, Bulgaria.

## 4 Semantic model of Bulgarian bells

### 4.1 Semantic web

The most widespread standards for the description of resources are SGML, XML, RDF, OWL etc. The Resource Description Framework (RDF) is a framework for describing and exchanging data. It offers a model and syntax for metadata, so that they can be used by independent components. At its core RDF contains nodes and attached there to pairs of attributes and values. Nodes can be any Web resources (pages, servers, virtually all of which can be given Universal Resource Identifier (URI), even other types of meta data). Attributes are properties of knots and their values are either atomistic (text strings, numbers etc) or other resources or meta data. This mechanism allows to build boxes (labeled directed graphs), which could later be converted into XML. For more information, see [10]. We make an experimental semantic annotation, based on the current W3C Semantic Web initiative standards (RDF, RDFS, OWL) of the resources in digital archive of unique bells. We use the RDF data model, because it provides a model for describing resources of bells. Digital resources have properties (attributes or characteristics of bells). RDF defines a digital resource as any object that is uniquely identifiable by an URI.

### 4.2 Basic ontology of Bulgarian bells

Using information of metadata annotation we make an ontology explain of Bulgarian bells. In Figure 3 is shown the basic schema between digital resources of

each bell.

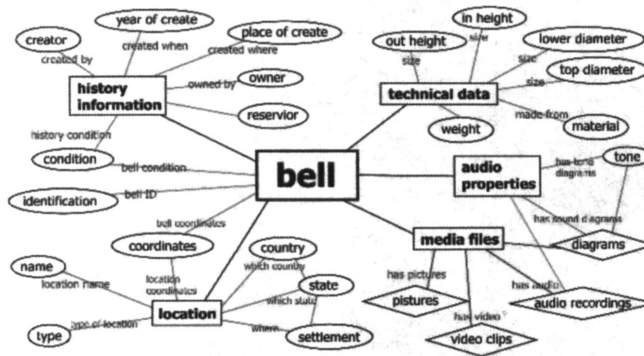


Figure 3: RDF/OWL scheme of digital resources.

Next is shown a part of RDF/XML data code from developed ontology of one settlement of bell:

```

<RDF:RDF>
  <RDF:Description RDF:Href = "http://www.math.bas.bg/bells/bell/">
    <bell:belfry RDF:Href = "#belfry"/>
    <bell:media-files RDF:Href = "#media-files"/>
    <bell:history-information RDF:Href = "#history-information"/>
    <bell:audio-characteristic RDF:Href = "#audio-characteristic"/>
    <bell:technical-data RDF:Href = "#technical-data"/>
  </RDF:Description>
  ...
  <RDF:Description ID="bell_01_01">
    <bell:name>bell N:01 from 01</bell:name>
    <bell:condition>good</bell:condition>
    <bell:coordinates>42°41'45.28'' N 23°19'57.36'' E </bell:coordinates>
    <loc:name> Alexander Nevsky Cathedral</loc:name>
    ...
    <ach:tone>Sol of great octave </ach:tone>
    <td:out-height>172.5</td:out-height>
    <td:in-height>163.1</td:in-height>
    <td:weight>6002</td:weight>
    <td:top-diameter>123</td:top-diameter>
    <td:down-diameter>226</td:down-diameter>
    <td:material> Lead alloy, silver and copper </td:material>
    <CARD:Affiliation>Home, Inc.</CARD:Affiliation>
  </RDF:Description>
</RDF:RDF>

```

In Figure 3 a part of representation of developed bell ontology system is shown.

## 5 Conclusion

Creation, optimization and protection of audio and video archive of valuable Bulgarian bells is an important and difficult task. Particularly significant is the

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