Poznań University of Technology

Faculty of Control, Robotics and Electrical Engineering

Institute of Robotics and Machine Intelligence

Division of Control and Industrial Electronics

Data-interchange format JSON

Mobile and embedded applications for Internet of Things

Teaching materials for laboratory

Dominik Łuczak, Ph.D.; Adrian Wójcik, M.Sc.

Dominik.Luczak@put.poznan.pl
Adrian.Wojcik@put.poznan.pl

I. Goal

Knowledge

The aim of the course is to familiarize yourself with:

- JSON format syntax,
- data formats used in IT systems,
- available methods of parsing data in JSON format.

Skills

The aim of the course is to acquire skills in:

- interpretation of data in JSON format,
- using the JSON format in mobile applications,
- simple data representation as structure in JSON format,
- complex data representation as structure in JSON format,

Social competences

The aim of the course is to develop proper attitudes:

- strengthening the understanding and awareness of the importance of non-technical aspects and effects of the engineer's activities and the related responsibility for the decisions taken,
- proper technical communication in the context of object-oriented data representation.

II. Laboratory report

Complete laboratory tasks as per the instructor's presentation. Work alone or in a team of two. **Keep safety rules while working!**. Prepare laboratory report documenting and proving the proper execution of tasks. Editorial requirements and a report template are available on the *eKursy* platform. The report is graded in two categories: tasks execution and editorial requirements. Tasks are graded as completed (1 point) or uncompleted (0 points). Compliance with the editorial requirements is graded as a percentage. The report should be sent as a *homework* to the *eKursy* platform by Sunday, March 21, 2021 by 23:59.

III. Prepare to course

a) Know the safety rules

All information on the laboratory's safety instructions are provided in the laboratory and on Division website [4]. All inaccuracies and questions should be clarified with the instructor. It is required to be familiar with and apply to the regulations.

Attend the class prepared. Knowledge from all previous topics is mandatory.

b) Introduction to the JSON format

JSON (JavaScript Object Notation) is an open standard for the format of computer data exchange in the form of human-readable text [3]. Objects in JSON format consist of attribute - value pairs. Listing 1. presents a simple object consisting of a single primitive.

Listing 1. Basics of JSON syntax - an object in the form of an attribute (key) / value pair.

```
{ "key" : "value" }
```

Formally, JSON is a subset of the JavaScript language, but in practice, it is a format independent of the programming language. One of the basic advantages of the format is the availability of libraries enabling its use, among others in C, C++, C#, Java, PHP, Python and many more. The basic application of the JSON format is data transfer in network applications based on the client-server model, including applications based on the REST (Representational State Transfer architecture). The technology is used by websites such as Google, YouTube, Twitter, Facebook and many more [1].

c) JSON syntax

The message in JSON format is an associative (associative) table. All data is variable, which means that the format does not allow the transfer of executable code. Attribute names (fields, components) are always surrounded by quotation marks. Subsequent attribute-value pairs are separated by a comma. There is no comma after the last element. Whitespace is ignored in the parsing process. The message is coded in Unicode and by default, it is UTF-8 [2]. There are four types of attribute values:

- string (text surrounded by quotation marks),
- number (an integer or a floating-point number with *dot*),
- boolean value (true or false),
- null value.

Listing 2. shows an example of an object in JSON format containing the address of Poznan University of Technology.

Listing 2. Poznan University of Technology address in JSON format.

```
{
  "street␣name" : "M.␣Sklodowska-Curie␣Square",
  "building␣number" : 5,
  "apartment␣number" : null,
  "post␣town" : "Poznan",
  "postcode" : "60-965"
}
```

The JSON format also allows data representation using arrays. The tables are an ordered list of data (not necessarily the same type!) Enclosed in square brackets and separated by a comma. Listing 3. shows an example of a simple array containing the names of the faculties of Poznan University of Technology.

Listing 3. An array containing the names of the faculties of Poznan University of Technology in JSON format.

```
[ "Architecture",
  "Control,␣Robotics␣and␣Electrical␣Engineering",
  "Computing␣and␣Telecommunications",
  "Civil␣and␣Transport␣Engineering",
  "Materials␣Engineering␣and␣Technical␣Physics",
  "Mechanical␣Engineering",
  "Environmental␣Engineering␣and␣Energy",
  "Engineering␣Management",
  "Chemical␣Technology"  ]
```

The basic property of the JSON format is the ability to nest objects freely. Listing 4. shows an example of nesting objects. Nesting arrays can be done in a similar way.

Listing 4. Nesting of objects in JSON format based on contact details of three selected faculties of Poznan University of Technology.

```
{
 "FCREE" : {
  "name": "Faculty␣of␣Control,␣Robotics␣and␣Electrical␣Engineering",
  "address" : "Piotrowo␣3A,␣60-965␣Poznan",
  "phone_number" : "+48␣61␣665␣25␣39"
 },

 "FCT" : {
  "name": "Faculty␣of␣Computing␣and␣Telecommunications",
  "address" : "Piotrowo␣3A,␣60-965␣Poznan",
  "phone_number" : "+48␣61␣665␣34␣20"
 },

 "FEM" : {
  "name": "Faculty␣of␣Engineering␣Management",
  "address" : "Piotrowo␣3,␣60-965␣Poznan",
  "phone_number" : "+48␣␣61␣665␣2360"
 }
}
```

The JSON format provides great freedom in how data is represented. The programmer's task is to properly analyze the problem and propose a form of data representation appropriate for the task.

IV. Scenario for the class

a) Teaching resources

Hardware
- computer,

Software
- source code editor (VS, Code, Notepad++).
- JSON parser (web application).

b) Tasks

Familiarize yourself with the JSON format syntax. Make a syntactic analysis of the presented examples using the parser indicated by the instructor (e.g. http://json.parser.online.fr/ or http://jsonviewer.stack.hu/).

1. A simple data structure in JSON format.
   (a) An object that stores information about colors.
      – Create a simple object containing information about the color in the RGB model (e.g. R = 0, G = 100, B = 200).
      – The object should consist of three numeric values: R, G, and B.
      – Verify object syntax using a parser.
   (b) Color array.
      – Create a simple array containing information about the color in the RGB model.
      – The array should consist of three numeric values.
      – Note how the two representations differ? Which character contains more information? Verify object syntax using a parser.

(c) An object that stores information about colors in the form of an array.
   - Create a simple object containing information about the color in the RGB model.
   - The object should consist of one attribute-value pair RGB with an array value.
   - Note how the two representations differ? Which character contains more information? Verify object syntax using a parser.

2. A complex data structure in JSON format.

   (a) Create an *object* consisting of RGB *objects* representing the set of colors (e.g. RGB1: R = 0, G = 0, B = 0; RGB2: R = 0, G = 100, B = 200; RGB3: R = 255, G = 255, B = 255; RGB4: R = 255, G = 0, B = 0). Each subobject should contain three numeric values: R, G, and B. Verify object syntax using a parser.

   (b) Create an *array* consisting of RGB *arrays* representing the set of colors. Verify object syntax using a parser.

   (c) Create an *object* consisting of RGB *arrays* representing the set of colors. Verify object syntax using a parser.

   (d) Create an *array* consisting of RGB *objects* representing the set of colors. Each sub-object should contain three numeric values: R, G, and B. Verify object syntax using a parser.

3. A complex problem of data representation.

   (a) Suggest a structure for representing your timetable in the current semester.

   (b) Note the data redundancy in the proposed representation. Consider the object-oriented application of data.

   (c) Create a data structure in JSON format to represent the required data.

   (d) Verify object syntax using a parser.

4. Data representation structure - embedded system.

   (a) Suggest a data format representing the state of digital I/Os. Use at least 4 inputs and 4 outputs.

   (b) Suggest a data format that represents the status of the analog inputs/outputs. Use at least 4 inputs and 4 outputs.

   (c) Extend the format of the digital I/O data with additional information indicated by the lecturer (e.g. device name, unique channel number, channel name, type of sensor/actuator, measurement frequency, date of last reading, activation level: low, high, slope, etc.).

   (d) Extend the format of the analog input/output data with additional information indicated by the lecturer (e.g. device name, unique channel number, channel name, type of sensor/actuator, resolution, accuracy, refresh rate, date of last input/output update, unit of the measured/set physical quantity, range: minimum and maximum value, type of input signal filtering, etc.).

   (e) Suggest a structure describing the measuring sensor indicated by the teacher (e.g. analog temperature sensor)

5. (*) Data representation structure for the Sense-HAT extension board. Based on the available device documentation (`https://www.raspberrypi.org/documentation/hardware/sense-hat/`) propose a transmitting and receiving data structure in JSON format

References

[1] *10 Example JSON FilesSitePoint*. URL: https://www.sitepoint.com/10-example-json-files/ (visited on 09/30/2011).

[2] *JSON*. URL: http://www.json.org/json-pl.html (visited on 09/30/2019).

[3] *JSON Wikipedia*. URL: https://en.wikipedia.org/w/index.php?title=JSON (visited on 09/30/2016).

[4] *Regulations, health and safety instructions*. URL: http://zsep.cie.put.poznan.pl/materialy-dydaktyczne/MD/Regulations-health-and-safety-instructions/ (visited on 09/30/2019).