

# Nano JSON

Working with JSON formatted data in Isabelle/HOL and Isabelle/ML

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## **Abstract**

JSON (JavaScript Object Notation) is a common format for exchanging data, based on a collection of key/value-pairs (the JSON objects) and lists. Its syntax is inspired by JavaScript with the aim of being easy to read and write for humans and easy to parse and generate for machines.

Despite its origin in the JavaScript world, JSON is language-independent and many programming languages support working with JSON-encoded data. This makes JSON an interesting format for exchanging data with Isabelle/HOL.

This AFP entry provides a JSON-like import-export format for both Isabelle/ML and Isabelle/HOL. On the one hand, this AFP entry provides means for Isabelle/HOL users to work with JSON encoded data without the need using Isabelle/ML. On the other and, the provided Isabelle/ML interfaces allow additional extensions or integration into Isabelle extensions written in Isabelle/ML. While format is not fully JSON compliant (e.g., due to limitations in the range of supported Unicode characters), it works in most situations: the provided implementation in Isabelle/ML and its representation in Isabelle/HOL have been used successfully in several projects for exchanging data sets of several hundredths of megabyte between Isabelle and external tools.

**Keywords:** JSON, JavaScript Object Notation, data exchange, data import, data export



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# 1 Introduction

JSON (JavaScript Object Notation) [5, 1] is a widely-used format for exchanging data, having replaced XML [2] in many areas. The structure of JSON is based on:

- A collection of key-value (name-value) pairs, also called JSON object. In programming languages, this corresponds, e.g., to data structures such as objects, records, structs, or hash tables.
- A finite list of values. In programming languages, this corresponds, e.g., to lists, sequences, or arrays.

The syntax of is inspired by JavaScript with the aim of being easy to read and write for humans (that are comfortable with curly-bracket programming languages) and easy to parse and generate for machines.

Despite its origin in the JavaScript world, JSON is language-independent and many programming languages support working with JSON-encoded data. This makes JSON an interesting format for exchanging data with Isabelle/HOL.

This AFP entry provides a JSON-like import-expert format for both Isabelle/ML and Isabelle/HOL. While this entry provides a simple formal model of JSON, formalizing an object-based data structure is not the aim of this AFP entry (for this, see, e.g., [4, 3]). The aim of this AFP entry is to provide means to work with JSON-encoded data in Isabelle, similar to the AFP entry “XML” [6] provides means to work with XML documents in Isabelle.

In more detail, this AFP entry provides two different ways for importing and exporting JSON-encoded data in Isabelle:

**Isabelle/HOL:** This AFP entry provides means for Isabelle/HOL users to work with JSON encoded data: it provides a HOL data type modelling the JSON format and new top-level Isar [7] commands to import and export JSON encoded files. Moreover, a new top-level Isar command is provided to parse JSON data that is stored “inline” within the Isabelle/HOL theory file.

**Isabelle/ML:** This AFP entry also provides interfaces to the underlying implementation in Isabelle/ML, allowing to write users to write their on extensions that require features not (yet) exposed to the Isabelle/HOL level. For example, data type packages for specific variants of JSON that, e.g., should directly map to specific HOL data types or that need further encoding or conversions during export or import.

While the supported JSON-variant is not fully JSON compliant (e.g., due to limitations in the range of supported Unicode characters), it works in most situations: the provided implementation in Isabelle/ML and its representation in Isabelle/HOL have been used successfully in several projects for exchanging data sets of several hundredths of megabyte between Isabelle and external tools.

In summary, Nano JSON should enable you to work with JSON encoded data in Isabelle/HOL without the need of implementing parsers or serialization in Isabelle/ML. You should be able to implement mapping from the Nano JSON HOL data types to your own data types on the level of Isabelle/HOL (i.e., as executable HOL functions). Nevertheless, the provided ML routine that converts between the ML representation and the HOL representation of Nano JSON can also serve as a starting point for converting the ML representation to your own, domain-specific, HOL encoding.

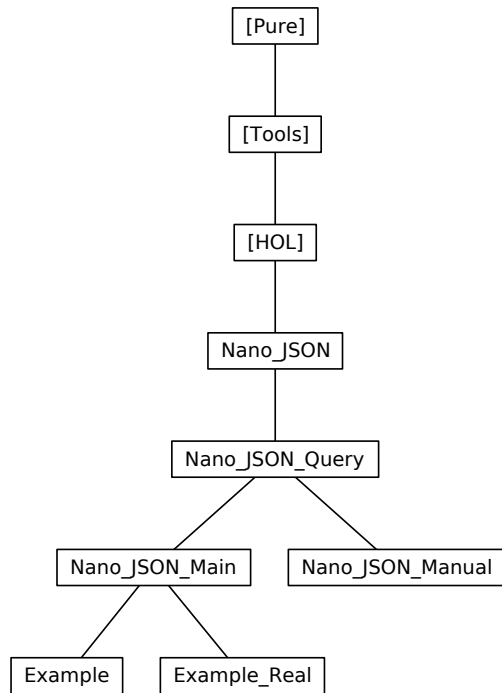


Figure 1.1: The Dependency Graph of the Isabelle Theories.

The rest of this document is automatically generated from the formalization in Isabelle/HOL, i.e., all content is checked by Isabelle. Overall, the structure of this document follows the theory dependencies (see Figure 1.1). If you want to understand the implementation of Nano JSON or want to use its API on the level of Isabelle/ML, you should consult chapter 2. If you are interested in using Nano JSON on the level of Isabelle/HOL or want to explore examples, please consult chapter 3.

## 2 Implementation

### 2.1 An Import/Export of JSON-like Formats for Isabelle/HOL (Nano\_JSON)

```
theory
  "Nano_JSON"
imports
  Main
keywords
  "JSON_file" :: thy_load
and "JSON" :: thy_decl
and "JSON_export" :: thy_decl
and "defining"::quasi_command
```

#### begin

This theory implements an import/export format for Isabelle/HOL that is inspired by JSON (JavaScript Object Notation). While the format defined in this theory is inspired by the JSON standard (<https://www.json.org>), it is not fully compliant. Most notably,

- only basic support for Unicode characters. In particular, JSON strings are mapped to a polymorphic type usually is either instantiated with the `string` or `String.literal`. Hence, the strings that can be represented in JSON are limited by the characters that Isabelle/HOL can handle (support on the Isabelle/ML level is less constrained).
- numbers are mapped to a polymorphic type, which can, e.g., be instantiated with
  - `real`. Note that this is not a faithful representation of IEEE754 floating point numbers that are assumed in the JSON standard. Moreover, this required that parent theories include `Complex_Main`.
  - `int`. This is recommended configuration, if the JSON files only contain integers as numerical data.
  - `string`. If not numerical operations need to be done, numerical values can also be encoded as HOL strings (or `String.literal`).

While the provided JSON import and export mechanism is not fully compliant to the JSON standard (hence, its name “Nano JSON”), it should work with most real-world JSON files. Actually, it has already served well in various projects, allowing us to simply exchange data between Isabelle/HOL and external tools.

#### 2.1.1 Defining a JSON-like Data Structure

We start by modelling a HOL data type for representing the abstract syntax of JSON, which consists out of objects, lists (called arrays), numbers, strings, and Boolean values.

## A HOL Data Type for JSON

```
datatype ('string, 'number) json =
  OBJECT "('string * ('string, 'number) json) list"
| ARRAY "('string, 'number) json list"
| NUMBER "number"
| STRING "string"
| BOOL "bool"
| NULL
```

Using the data type ('string, 'number) json, we can now represent JSON encoded data easily in HOL, e.g., using the concrete instance (string, int) json:

```
definition example01::<(string, int) json> where
"example01 =
  OBJECT [('menu', OBJECT [('id', STRING 'file'), ('value', STRING 'File'),
    ('popup', OBJECT [('menuitem', ARRAY
      [OBJECT [('value', STRING 'New'),
        ('onclick', STRING 'CreateNewDoc()')]),
      OBJECT [('value', STRING 'Open'),
        ('onclick', STRING 'OpenDoc()')]),
      OBJECT [('value', STRING 'Close'),
        ('onclick', STRING 'CloseDoc()')])])])],
    ('flag', BOOL True), ('number', NUMBER 42)
]"
```

## ML Implementation

The translation of the data type ('string, 'number) json to Isabelle/ML is straight forward with the exception that we do not need to distinguish different String representations. In addition, we also provide methods for converting JSON instances between the representation as Isabelle terms and the representation as Isabelle/ML data structure.

```
ML<
signature NANO_JSON_TYPE = sig
  datatype NUMBER = INTEGER of int | REAL of IEEEReal.decimal_approx
  datatype json = OBJECT of (string * json) list
    | ARRAY of json list
    | NUMBER of NUMBER
    | STRING of string
    | BOOL of bool
    | NULL

  val term_of_real: bool -> IEEEReal.decimal_approx -> term
  val term_of_json: bool -> typ -> typ -> json -> term
  val json_of_term: term -> json
end
>
```

**ML\_file** Nano\_JSON\_Type.ML

The file Nano\_JSON\_Type.ML provides the Isabelle/ML structure Nano\_Json\_Type:NANO\_JSON\_TYPE. When first argument of the functions Nano\_Json\_Type.term\_of\_real and Nano\_Json\_Type.term\_of\_json is true,

then warnings are reported to the the output window of Isabelle. Otherwise, warning will be ignored. Furthermore, the two arguments of type `typ` of the function `Nano_Json_Type.term_of_json` represent the HOL target type for JSON strings and numerical values. An example invocation of this function looks as follows:

```
ML<Nano_Json_Type.term_of_json false @{typ "string"} @{typ <int>} Nano_Json_Type.NULL>
```

## 2.1.2 Parsing Nano JSON

In this section, we define the infrastructure for parsing JSON-like data structures as well as for importing them into Isabelle/HOL. This implementation was inspired by the “Simple Standard ML JSON parser” from Chris Cannam.

### ML Implementation

**Configuration Attributes.** We start by preparing the infrastructure for three configuration attributes, using the Isabelle/Isar attribute mechanism:

```
ML<
  val json_num_type = let
    val (json_num_type_config, json_num_type_setup) =
      Attrib.config_string (Binding.name "JSON_num_type") (K "int")
  in
    Context.>>(Context.map_theory json_num_type_setup);
    json_num_type_config
  end
>
```

The attribute “JSON\_num\_type” (default `int`) allows for configuring the HOL-type used representing JSON numerals.

```
ML<
  val json_string_type = let
    val (json_string_type_config, json_string_type_setup) =
      Attrib.config_string (Binding.name "JSON_string_type") (K "string")
  in
    Context.>>(Context.map_theory json_string_type_setup);
    json_string_type_config
  end
>
```

The attribute “JSON\_string\_type” (default `string`) allows for configuring the HOL-type used representing JSON string.

```
ML<
  val json_verbose = let
    val (json_string_type_config, json_string_type_setup) =
      Attrib.config_bool (Binding.name "JSON_verbose") (K false)
  in
    Context.>>(Context.map_theory json_string_type_setup);
    json_string_type_config
  end
>
```

The Boolean attribute “JSON\_verbose” (default: `false`) allows for enabling warnings during the JSON processing.

**Lexer.** The following Isabelle/ML signatures captures the lexer:

```
ML<
signature NANO_JSON_LEXER = sig
  structure T : sig
    datatype token = NUMBER of char list
                  | STRING of string
                  | BOOL of bool
                  | NULL
                  | CURLY_L
                  | CURLY_R
                  | SQUARE_L
                  | SQUARE_R
                  | COLON
                  | COMMA

    val string_of_T : token -> string
  end
  val tokenize_string: string -> T.token list
end
>
```

**ML\_file** Nano\_JSON\_Lexer.ML

The file Nano\_JSON\_Lexer.ML provides the Isabelle/ML structure Nano\_Json\_Lexer : NANO\_JSON\_LEXER. It provides the function Nano\_Json\_Lexer.tokenize\_string which, as the name suggests, tokenizes a string (containing a JSON object).

ML<

```
signature NANO_JSON_PARSER = sig
  val json_of_string : string -> Nano_Json_Type.json
  val term_of_json_string : bool -> typ -> typ -> string -> term
  val numT: theory -> typ
  val stringT: theory -> typ
end
>
```

**ML\_file** "Nano\_JSON\_Parser.ML"

The file Nano\_JSON\_Parser.ML provides the Isabelle/ML structure Nano\_Json\_Parser : NANO\_JSON\_PARSER. The two main functions:

- First, Nano\_Json\_Parser.json\_of\_string parsing a string (containing a JSON object) and returning its abstract syntax (i.e., an instance of the type Nano\_Json\_Type.json.
- Second, Nano\_Json\_Parser.term\_of\_json\_string, which parses a string into a HOL term. As for Nano\_Json\_Type.term\_of\_json, the first argument decides if warnings are printed and the next two arguments determine the HOL type representations for JSON strings and numerical values.

The parser MLNano\_Json\_Parser.term\_of\_json\_string can now be used, on the Isabelle/ML-level as follows:

ML<

```
Nano_Json_Parser.term_of_json_string true (@{typ string}) (@{typ int})
```

```
"{\\"name\\": [true,false,\\\"test\\\"]}"
```

```
,
```

## Isar Setup: Cartouche and Isar-Top-level Binding

**The JSON Cartouche.** First, we define a cartouche that allows using JSON syntax within HOL expressions:

```
syntax "_cartouche_nano_json" :: "cartouche_position  $\Rightarrow$  'a" (<JSON _>)  
parse_translation  
let  
  fun translation u args = let  
    val thy = Context.the_global_context u  
    val verbose = Config.get_global thy json_verbose  
    val strT = Nano_Json_Parser.stringT thy  
    val numT = Nano_Json_Parser.numT thy  
    fun err () = raise TERM ("Common._cartouche_nano_json", args)  
    fun input s pos = Symbol_Pos.implode (Symbol_Pos.cartouche_content  
                                           (Symbol_Pos.explode (s, pos)))  
  
  in  
    case args of  
      [(c as Const (@{syntax_const "_constrain"}, _)) $ Free (s, _) $ p] =>  
        (case Term_Position.decode_position1 p of  
          SOME {pos, ...} => c  
            $ Nano_Json_Parser.term_of_json_string verbose strT numT (input s  
pos)  
          | NONE => err ())  
        | _ => err ()  
    end  
  in  
    [(@{syntax_const "_cartouche_nano_json"}, K (translation ()))]  
  end  
,
```

In the following, we briefly illustrate the use of the JSON cartouche and the attribute for mapping JSON types to HOL types:

```
declare [[JSON_string_type = string]]  
lemma <y == JSON <{"name": true}> >  
  oops  
  
declare [[JSON_string_type = String.literal]]  
lemma <y == JSON <{"name": true}> >  
  oops  
declare [[JSON_string_type = string]]  
  
lemma <y == JSON<{"name": [true,false,"test"]}> >  
  oops  
lemma <y == JSON<{"name": [true,false,"test"],  
                  "bool": true,  
                  "number" : 1 }> >  
  oops
```

**Isar Top-Level Commands.** Furthermore, we define two Isar top-level commands: one that allows for importing JSON data from the file system, and one for defining JSON “inline” within Isabelle theory files.

ML<

```
structure Nano_Json_Parser_Isar = struct
  fun make_const_def (binding, trm) lthy = let
    val lthy' = snd ( Local_Theory.begin_nested lthy )
    val arg = ((binding, NoSyn),
              ((Thm.def_binding binding, [Code.singleton_default_equation_attrib]),
              trm))
    val ((_, ( _ , thm)), lthy'') = Local_Theory.define arg lthy'
  in
    (thm, Local_Theory.end_nested lthy'')
  end

  fun def_json name json lthy = let
    val thy = Proof_Context.theory_of lthy
    val strT = Nano_Json_Parser.stringT thy
    val numT = Nano_Json_Parser.numT thy
    val verbose = Config.get_global thy json_verbose
  in
    (snd o (make_const_def (Binding.name name,
                          Nano_Json_Parser.term_of_json_string verbose strT numT json)))

    lthy
  end

  val typeCfgParse = Scan.optional
    (Args.parens (Parse.name -- Args.$$$ " ," -- Parse.name))
    (("" , "" ), "");
  val jsonP = (Parse.name -- Parse.cartouche)

end
>
```

ML<

```
val _ = Outer_Syntax.local_theory @{command_keyword "JSON"}
  "Define JSON."
  ((Parse.cartouche -- keyword <defining> -- Parse.name) >> (fn ((json, _), name)
=> Nano_Json_Parser_Isar.def_json name json))

val _ = Outer_Syntax.command command_keyword <JSON_file>
  "Import JSON and bind it to a definition."
  ((Resources.parse_file -- keyword <defining> -- Parse.name) >>
  (fn ((get_file, _), name) =>
    Toplevel.theory (fn thy =>
      let
        val ({lines, ...}:Token.file) = get_file thy;
        val thy'' = Named_Target.theory_map
          (Nano_Json_Parser_Isar.def_json name (String.concat lines))
          thy
      in thy'' end)))
```

>

## Examples

Now we can use the JSON Cartouche for defining JSON-like data “on-the-fly”. Note that you need to escape quotes within the JSON Cartouche, if you are using quotes as lemma delimiters, e.g.,:

```
lemma "y == JSON<{"name": [true,false,"test"]}>"
  oops
```

Thus, we recommend to use the Cartouche delimiters when using the JSON Cartouche with non-trivial data structures:

```
lemma < example01 == JSON <{"menu": {
  "id": "file",
  "value": "File",
  "popup": {
    "menuitem": [
      {"value": "New", "onclick": "CreateNewDoc()"},
      {"value": "Open", "onclick": "OpenDoc()"},
      {"value": "Close", "onclick": "CloseDoc()"}
    ]
  }
},
  "flag": true,
  "number": 42
}>>
by(simp add: example01_def)
```

We can define new JSON data “inline”, using the Isar keyword **JSON**:

```
JSON <
{"menu": {
  "id": "file",
  "value": "File",
  "popup": {
    "menuitem": [
      {"value": "New", "onclick": "CreateNewDoc()"},
      {"value": "Open", "onclick": "OpenDoc()"},
      {"value": "Close", "onclick": "CloseDoc()"}
    ]
  }
}, "flag":true, "number":42}
> defining example04
```

Moreover, we can define new JSON data by reading it from a file, using the Isar keyword **JSON\_file**:

```
JSON_file "example.json" defining example03
```

```
thm example03_def example04_def
```

```
lemma "example03 = example04"
  by (simp add:example03_def example04_def)
```

### 2.1.3 Serializing Nano JSON

In this section, we define the necessary infrastructure to serialize (export) data from HOL using a JSON-like data structure that other JSON tools should be able to import.

#### ML Implementation

```
ML<
signature NANO_JSON_SERIALIZER = sig
  val serialize_json: Nano_Json_Type.json -> string
  val serialize_json_pretty: Nano_Json_Type.json -> string
  val serialize_term: term -> string
  val serialize_term_pretty: term -> string
end
>
```

**ML\_file** "Nano\_JSON\_Serializer.ML"

The file `Nano_JSON_Serializer.ML` provides the Isabelle/ML structure `Nano_Json_Serializer:NANO_JSON_SERIALIZER`. It provides functions for serializing JSON data from its abstract syntax as well as from its HOL term representations. Moreover, variants are provided that try to pretty print the output with the goal of making it easier to read for humans.

#### Isar Setup

```
ML<
structure Nano_Json_Serialize_Isar = struct
  fun export_json thy json_const filename =
    let
      val term = Thm.concl_of (Global_Theory.get_thm thy (json_const^"_def"))
      fun export binding content thy =
        let
          val thy' = thy |> Generated_Files.add_files (binding, content);
          val _ = Export.export thy' binding (Bytes.contents_blob content)
        in thy' end;
      val json_term = case term of
        Const (@{const_name "Pure.eq"}, _) $ _ $ json_term => json_term
      | _ $ (_ $ json_term) => json_term
      | _ => error ("Term structure not supported.")
      val json_string = Nano_Json_Serializer.serialize_term_pretty json_term
      val json_bytes = Bytes.string (Protocol_Message.clean_output json_string)
    in
      case filename of
        SOME filename => let
          val filename = Path.explode (filename^".json")
          val thy' = export (Path.binding
            (Path.append (Path.explode "json")
              filename,Position.none))
            json_bytes thy
          val _ = writeln (Export.message thy (Path.basic "json"))
        in
          thy'
        end
    end
end
```

```

        end
      | NONE => (tracing json_string; thy)
    end
  end
end
>

ML<
Outer_Syntax.command ("JSON_export", Position.none)
"export JSON data to an external file"
((Parse.name -- Scan.option (keyword <file>-- Parse.name))
 >> (fn (const_name,filename) =>
      (Toplevel.theory (fn state => Nano_Json_Serialize_Isar.export_json state
                                const_name (Option.map snd filename))))));
>

```

## Examples

We can now serialize JSON and print the result in the output window of Isabelle/HOL:

```

JSON_export example01
thm example01_def

```

Alternatively, we can export the serialized JSON into a file:

```

JSON_export example01 file example01

```

### 2.1.4 Putting Everything Together

For convenience, we provide an ML structure that provides access to both the parser and the serializer:

```

ML<
structure Nano_Json = struct
  open Nano_Json_Type
  open Nano_Json_Parser
  open Nano_Json_Serializer
end
>

end

```

## 2.2 Query Infrastructure (Nano\_JSON\_Query)

```

theory
  Nano_JSON_Query
imports
  Nano_JSON
begin

```

In this theory, we define various functions for working with JSON data, i.e., the data types defined in the theory `Nano_JSON.Nano_JSON`. These query functions are useful for building more complex functionality of JSON encoded data. One could think of them as something like `jq` (<https://stedolan.github.io/jq/>) for Isabelle.

## Isabelle/ML

ML<

```
signature NANO_JSON_QUERY = sig
  val nj_filter:
    string -> Nano_Type.json
    -> (string list * Nano_Type.json) list
  val nj_filterp:
    string list -> Nano_Type.json
    -> (string list * Nano_Type.json) list
  val nj_filter_obj:
    (string * Nano_Type.json option) -> Nano_Type.json
    -> (string list * Nano_Type.json) list
  val nj_filterp_obj:
    (string list * Nano_Type.json option) -> Nano_Type.json
    -> (string list * Nano_Type.json) list
  val nj_first_value_of:
    string -> Nano_Type.json
    -> Nano_Type.json option
  val nj_first_value_ofp:
    string list -> Nano_Type.json
    -> Nano_Type.json option
  val nj_update:
    (Nano_Type.json -> Nano_Type.json) -> string -> Nano_Type.json
    -> Nano_Type.json
  val nj_updatep:
    (Nano_Type.json -> Nano_Type.json) -> string list -> Nano_Type.json
    -> Nano_Type.json
  val nj_convert:
    (Nano_Type.json -> 'a) -> string -> Nano_Type.json
    -> 'a list
  val nj_string_of:
    Nano_Type.json
    -> string option
  val nj_string_of':
    string -> Nano_Type.json -> string
  val nj_integer_of:
    Nano_Type.json -> int option
  val nj_integer_of':
    int -> Nano_Type.json -> int
  val nj_real_of:
    Nano_Type.json -> IEEEReal.decimal_approx option
  val nj_real_of':
    IEEEReal.decimal_approx -> Nano_Type.json -> IEEEReal.decimal_approx
  val nj_bool_of:
    Nano_Type.json -> bool option
  val nj_bool_of':
    bool -> Nano_Type.json -> bool
end
>
```

**ML\_file** Nano\_JSON\_Query.ML

The file Nano\_JSON\_Query.ML provides the Isabelle/ML structure Nano\_Json\_Query:NANO\_JSON\_QUERY.

### Isabelle/HOL

```
fun nj_filter':: <'a ⇒ 'a list × ('a, 'b) json ⇒ ('a list × ('a, 'b) json) list>
  where
    <nj_filter' key (prfx, OBJECT json) = ((map (λ (k,v). (prfx@[k],v)) (filter (λ (k,_). key
= k) json) )
      @ (List.concat (map (nj_filter' key) (map (λ (k,v). (prfx,v)) json)))
    )>
    | <nj_filter' key (prfx, ARRAY json) = (List.concat (map (nj_filter' key) (map (λ v. (prfx,v))
json)))>
    | <nj_filter' _ (_, NUMBER _) = []>
    | <nj_filter' _ (_, STRING _) = []>
    | <nj_filter' _ (_, BOOL _) = []>
    | <nj_filter' _ (_, NULL) = []>
```

```
definition nj_filter::<'a ⇒ ('a, 'b) json ⇒ ('a list × ('a, 'b) json) list> where
  <nj_filter key json = nj_filter' key ([],json)>
```

```
fun nj_update :: <(('a, 'b) json ⇒ ('a, 'b) json) ⇒ 'a ⇒ ('a, 'b) json ⇒ ('a, 'b) json>
  where
    <nj_update f key (OBJECT kjson) = OBJECT (map (λ (k,json). if k = key
      then (k, f json)
      else (k, nj_update f key json))
kjson)>
    | <nj_update f key (ARRAY json) = ARRAY (map (nj_update f key) json)>
    | <nj_update _ _ (NUMBER n) = NUMBER n>
    | <nj_update _ _ (STRING s) = STRING s>
    | <nj_update _ _ (BOOL b) = BOOL b>
    | <nj_update _ _ NULL = NULL>
```

**Examples.** The following illustrates a simple example of the nj\_filter function.

```
declare [[JSON_string_type=String.literal]]
```

```
JSON <
{"menu": {
  "id": "file",
  "value": "File",
  "popup": {
    "menuitem": [
      {"value": "New", "onclick": "CreateNewDoc()"},
      {"value": "Open", "onclick": "OpenDoc()"},
      {"value": "Close", "onclick": "CloseDoc()"}
    ]
  }
}, "flag":true, "number":42}
> defining example_literal_literal
```

```
value <nj_filter (STR ''onclick'') example_literal_literal>  
end
```

## 2.3 The Main Theory of Nano JSON (Nano\_JSON\_Main)

```
theory  
  Nano_JSON_Main  
imports  
  Nano_JSON_Query  
begin  
  This is the main entry point into the Nano_JSON session for users of this AFP entry.  
end
```

## 3 User's Guide and Examples

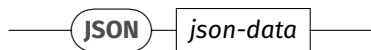
### 3.1 The Nano JSON Manual (Nano\_JSON\_Manual)

```
theory
  Nano_JSON_Manual
imports
  Nano_JSON_Query
begin
```

#### 3.1.1 Isabelle/HOL

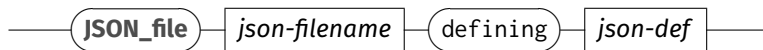
On the Isabelle/HOL level, we provide three new commands for working with JSON formatted data.

**JSON.** For defining JSON data within HOL terms, we provide the following command:



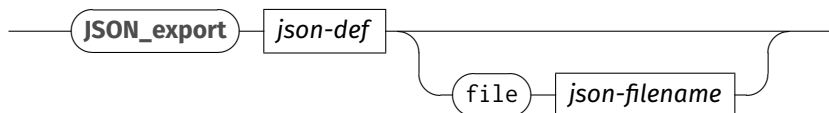
where *json-data* is a cartouche containing the JSON data.

**JSON\_file.** For reading JSON data from an external file, we provide the command



where *json-filename* is the path (file name) of the JSON file that should be read and *json-def* is the name the HOL definition representing the JSON data is bound to.

**JSON\_export.** For serializing (exporting) JSON encoded data, we provide the command



where *json-def* is the definition of the JSON data that should be exported. Optionally a file name (*json-filename*) can be provided. If a file name is provided, it is used for storing the serialized data in Isabelle's virtual file system. If no file name is provided, the serialized data is printed in Isabelle's output window.

**Configuration.** We provide three configuration attributes:

- The attribute `JSON_num_type` (default `int`) allows for configuring the HOL-type used representing JSON numerals.
- The attribute `JSON_string_type` (default `string`) allows for configuring the HOL-type used representing JSON string.
- The attribute `JSON_verbose` (default: `false`) allows for enabling warnings during the JSON processing.

### 3.1.2 Isabelle/ML

We refer users who want to use or extend Nano JSON on the Isabelle/ML level to the ML signatures shown in the implementation chapter, i.e., chapter 2.

end

## 3.2 Examples (Example)

```
theory
  Example
imports
  Nano_JSON_Main
begin
```

In this theory, we illustrate various small examples of importing or exporting of JSON data from Isabelle/HOL. The examples in this theory do not use the type `real` to avoid the need to depend on the theory “Complex\_Main”.

```
JSON <
{"menu": {
  "id": "file",
  "value": "File",
  "popup": {
    "menuitem": [
      {"value": "New", "onclick": "CreateNewDoc()"},
      {"value": "Open", "onclick": "OpenDoc()"},
      {"value": "Close", "onclick": "CloseDoc()"}
    ]
  }
}, "flag":true, "number": -42}
> defining example_default
thm example_default_def
JSON_export example_default
JSON_export example_default file example_default

declare [[JSON_string_type=string, JSON_num_type = nat]]
JSON <
{"menu": {
  "id": "file",
  "value": "File",
  "popup": {
```

```

    "menuitem": [
      {"value": "New", "onclick": "CreateNewDoc()"},
      {"value": "Open", "onclick": "OpenDoc()"},
      {"value": "Close", "onclick": "CloseDoc()"}
    ]
  }
}, "flag":true, "number": 42}
> defining example_string_nat
thm example_string_nat_def
JSON_export example_string_nat
JSON_export example_string_nat file example_string_nat

declare [[JSON_string_type=string, JSON_num_type = int]]
JSON <
{"menu": {
  "id": "file",
  "value": "File",
  "popup": {
    "menuitem": [
      {"value": "New", "onclick": "CreateNewDoc()"},
      {"value": "Open", "onclick": "OpenDoc()"},
      {"value": "Close", "onclick": "CloseDoc()"}
    ]
  }
}
}, "flag":true, "number":42}
> defining example_string_int

thm example_string_int_def
JSON_export example_string_int
JSON_export example_string_int file example_string_int

declare [[JSON_string_type=String.literal, JSON_num_type = int]]
JSON <
{"menu": {
  "id": "file",
  "value": "File",
  "popup": {
    "menuitem": [
      {"value": "New", "onclick": "CreateNewDoc()"},
      {"value": "Open", "onclick": "OpenDoc()"},
      {"value": "Close", "onclick": "CloseDoc()"}
    ]
  }
}
}, "flag":true, "number":42}
> defining example_literal_int
thm example_literal_int_def
JSON_export example_literal_int
JSON_export example_literal_int file example_literal_int

declare [[JSON_string_type=string, JSON_num_type = string]]
JSON <
{"menu": {

```

```

    "id": "file",
    "value": "File",
    "popup": {
      "menuitem": [
        {"value": "New", "onclick": "CreateNewDoc()"},
        {"value": "Open", "onclick": "OpenDoc()"},
        {"value": "Close", "onclick": "CloseDoc()"}
      ]
    }
  }, "flag":true, "number":-42}
> defining example_string_string
thm example_string_string_def
JSON_export example_string_string
JSON_export example_string_string file example_string_string

declare [[JSON_string_type=String.literal, JSON_num_type = String.literal]]
JSON <
{"menu": {
  "id": "file",
  "value": "File",
  "popup": {
    "menuitem": [
      {"value": "New", "onclick": "CreateNewDoc()"},
      {"value": "Open", "onclick": "OpenDoc()"},
      {"value": "Close", "onclick": "CloseDoc()"}
    ]
  }
}
}, "flag":true, "number":42}
> defining example_literal_literal
thm example_literal_literal_def
JSON_export example_literal_literal
JSON_export example_literal_literal file example_literal_literal

xxxx

```

Using the top level Isar commands defined in the last section, we can now easily define JSON-like data:

```

JSON <
{"menu": {
  "id": "file",
  "value": "File",
  "popup": {
    "menuitem": [
      {"value": "New", "onclick": "CreateNewDoc()"},
      {"value": "Open", "onclick": "OpenDoc()"},
      {"value": "Close", "onclick": "CloseDoc()"}
    ]
  }
}
}, "flag":true, "number":42}
> defining example02

thm example02_def

```

```

declare [[JSON_string_type = String.literal]]
JSON <
{"menu": {
  "id": "file",
  "value": "File",
  "popup": {
    "menuitem": [
      {"value": "New", "onclick": "CreateNewDoc()"},
      {"value": "Open", "onclick": "OpenDoc()"},
      {"value": "Close", "onclick": "CloseDoc()"}
    ]
  }
}, "flag":true, "number":42}
> defining example02'

thm example02'_def

```

```

ML<
@{term <JSON<{"number":31}>>}
>

```

Moreover, we can import JSON from external files:

```

lemma "example01 = example03"
by(simp add: example01_def example03_def)

```

**end**

### 3.3 Examples Real (Example\_Real)

```

theory
  Example_Real
imports
  Nano_JSON_Main
  Complex_Main
begin

```

In this theory, we illustrate various small examples of importing or exporting of JSON data from Isabelle/HOL. The examples in this theory make use `real`. This is possible, as this theory imports the theory `Complex_Main`.

```

declare [[JSON_num_type = real]]

JSON <
{"menu": {
  "id": "file",
  "value": "File",
  "popup": {
    "menuitem": [
      {"value": "New", "onclick": "CreateNewDoc()"},
      {"value": "Open", "onclick": "OpenDoc()"},
      {"value": "Close", "onclick": "CloseDoc()"}
    ]
  }
}

```

```

    }
  }, "flag":true, "number":-42.8}
> defining example_default_real

thm example_default_real_def

JSON_export example_default_real
JSON_export example_default_real file example_default_real

declare [[JSON_string_type=string, JSON_num_type = int]]
JSON <
{"menu": {
  "id": "file",
  "value": "File",
  "popup": {
    "menuitem": [
      {"value": "New", "onclick": "CreateNewDoc()"},
      {"value": "Open", "onclick": "OpenDoc()"},
      {"value": "Close", "onclick": "CloseDoc()"}
    ]
  }
}
}, "flag":true, "number":42}
> defining example_string_int
thm example_string_int_def
JSON_export example_string_int
JSON_export example_string_int file example_string_int

declare [[JSON_string_type=String.literal, JSON_num_type = int]]
JSON <
{"menu": {
  "id": "file",
  "value": "File",
  "popup": {
    "menuitem": [
      {"value": "New", "onclick": "CreateNewDoc()"},
      {"value": "Open", "onclick": "OpenDoc()"},
      {"value": "Close", "onclick": "CloseDoc()"}
    ]
  }
}
}, "flag":true, "number":42}
> defining example_literal_int

thm example_literal_int_def
JSON_export example_literal_int
JSON_export example_literal_int file example_literal_int

declare [[JSON_string_type=string, JSON_num_type = real]]
JSON <
{"menu": {
  "id": "file",
  "value": "File",
  "popup": {
    "menuitem": [

```

```

        {"value": "New", "onclick": "CreateNewDoc()"},
        {"value": "Open", "onclick": "OpenDoc()"},
        {"value": "Close", "onclick": "CloseDoc()"}
    ]
}
}, "flag":true, "number": 42.8}
> defining example_string_real
thm example_string_real_def
JSON_export example_string_real
JSON_export example_string_real file example_string_real

declare [[JSON_string_type=String.literal, JSON_num_type = real]]
JSON <
{"menu": {
  "id": "file",
  "value": "File",
  "popup": {
    "menuitem": [
      {"value": "New", "onclick": "CreateNewDoc()"},
      {"value": "Open", "onclick": "OpenDoc()"},
      {"value": "Close", "onclick": "CloseDoc()"}
    ]
  }
}
}, "flag":true, "number":42.8}
> defining example_literal_real
thm example_literal_real_def
JSON_export example_literal_real
JSON_export example_literal_real file example_literal_real

declare [[JSON_string_type=string, JSON_num_type = string]]
JSON <
{"menu": {
  "id": "file",
  "value": "File",
  "popup": {
    "menuitem": [
      {"value": "New", "onclick": "CreateNewDoc()"},
      {"value": "Open", "onclick": "OpenDoc()"},
      {"value": "Close", "onclick": "CloseDoc()"}
    ]
  }
}
}, "flag":true, "number":-42.5}
> defining example_string_string
thm example_string_string_def
JSON_export example_string_string
JSON_export example_string_string file example_literal_string

declare [[JSON_string_type=String.literal, JSON_num_type = String.literal]]
JSON<
{"menu": {
  "id": "file",
  "value": "File",

```

```
"popup": {
  "menuitem": [
    {"value": "New", "onclick": "CreateNewDoc()"},
    {"value": "Open", "onclick": "OpenDoc()"},
    {"value": "Close", "onclick": "CloseDoc()"}
  ]
}
}, "flag":true, "number":-42.5}
> defining example_literal_literal
thm example_literal_literal_def
JSON_export example_literal_literal
JSON_export example_literal_literal file example_literal_literal

end
```

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