NPRG039

Advanced Aspects and New Trends in XML (and Related) Technologies

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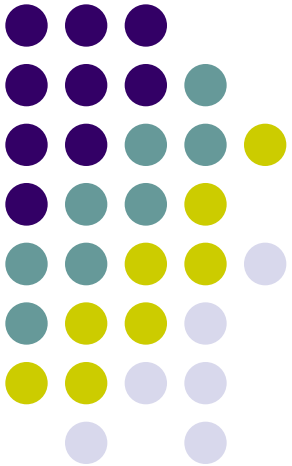


Lecture 2. JSON

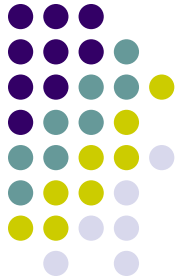
http://www.ksi.mff.cuni.cz/~holubova/NPRG039/

JSON (JavaScript Object Notation)

- Text-based easy-to-read-and-write open standard for data interchange
  - Serializing and transmitting structured data
  - Considered as an alternative to XML
- Filename: `*.json`
- Internet media type (MIME type): `application/json`
- Derived from JavaScript scripting language
- Language independent
  - But uses conventions of the C-family of languages (C, C++, C#, Java, JavaScript, Perl, Python, …)
- Originally specified by Douglas Crockford in 2001
  - RFC 4627
    - Requests for comments = "standard" publication of the Internet Engineering Task Force and the Internet Society

http://www.json.org/

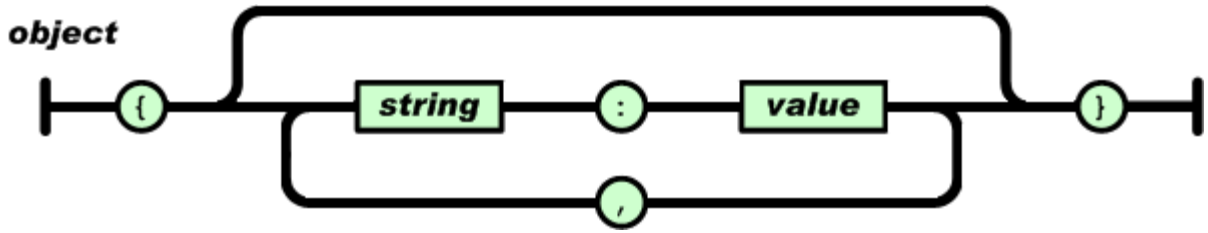
JSON – Basic Structures



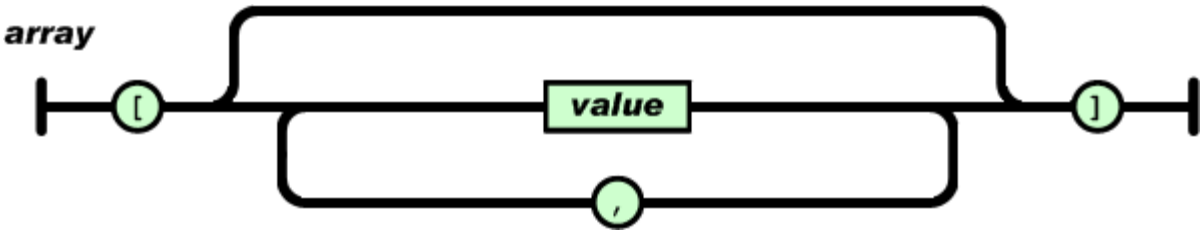
- Built on two general structures:
  - Collection of name/value pairs
    - Realized as an object, record, struct, dictionary, hash table, keyed list, associative array, …
  - Ordered list of values
    - Realized as an array, vector, list, sequence, …
- Universal data structures
  - All modern programming languages support them

JSON – Basic Data Types

- object – an unordered set of name/value pairs
  - called properties (members) of an object
  - { comma-separated name : value pairs }



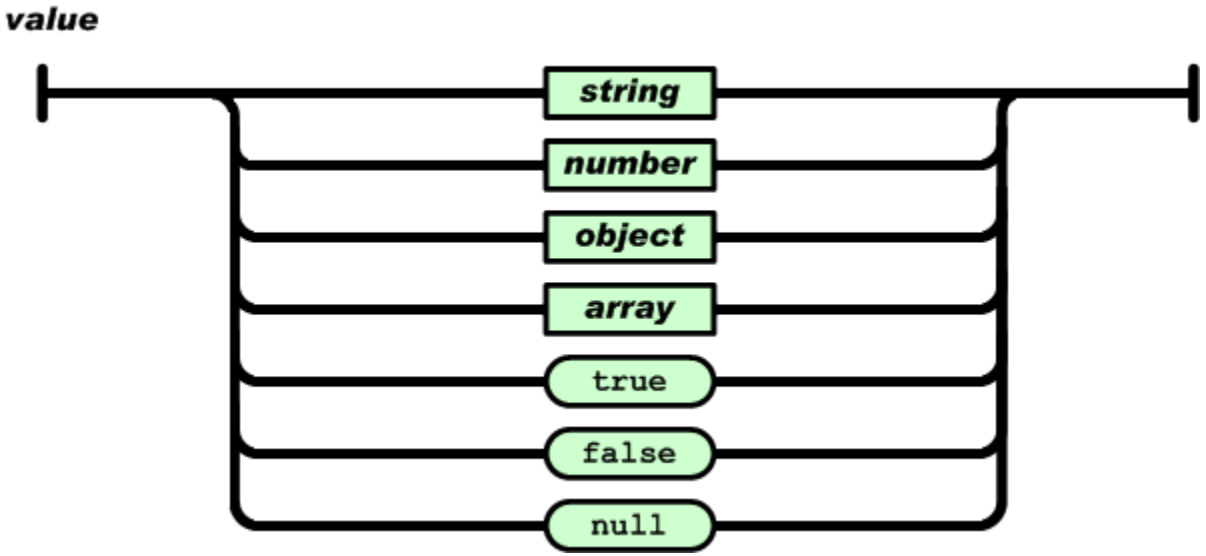
- array – an ordered collection of values
  - called items (elements) of an array
  - [comma-separated values]



JSON – Basic Data Types

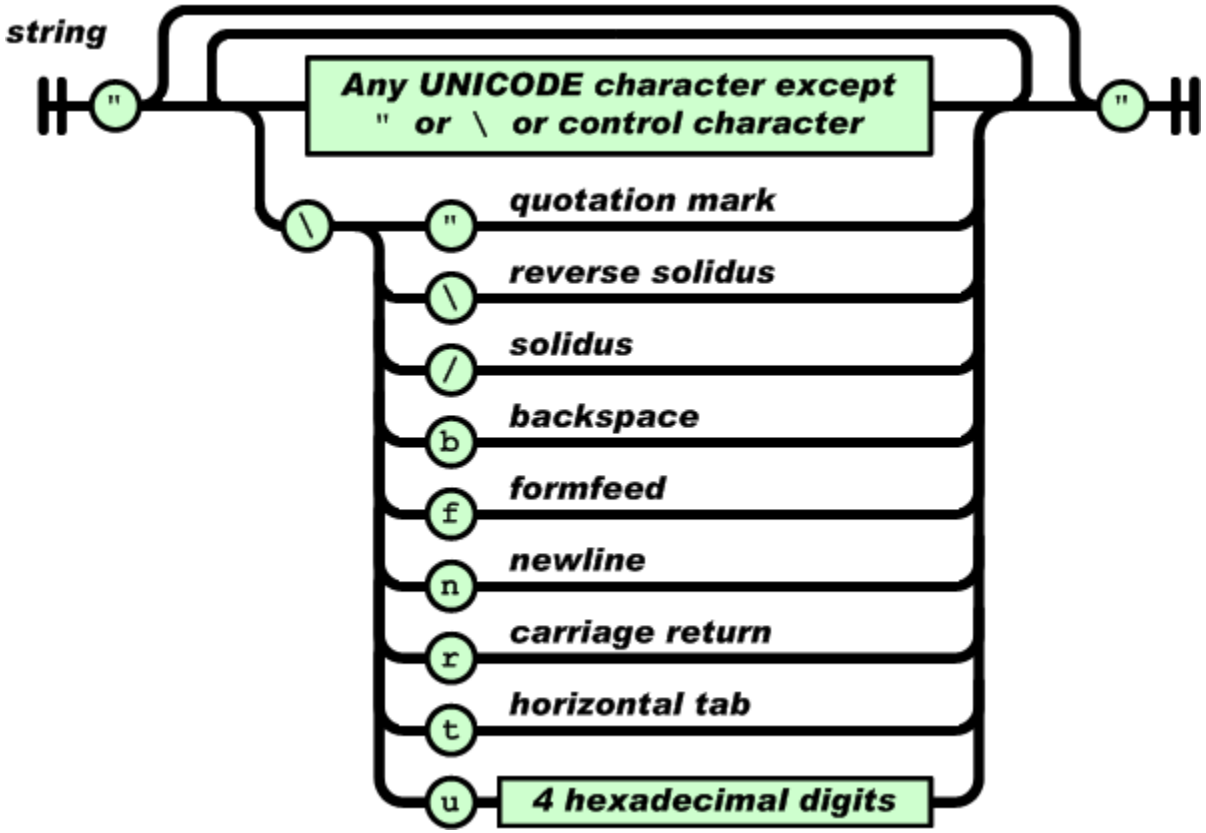
- value – string in double quotes / number / true or false (i.e., Boolean) / null / object / array
  - Can be nested

XML subelements



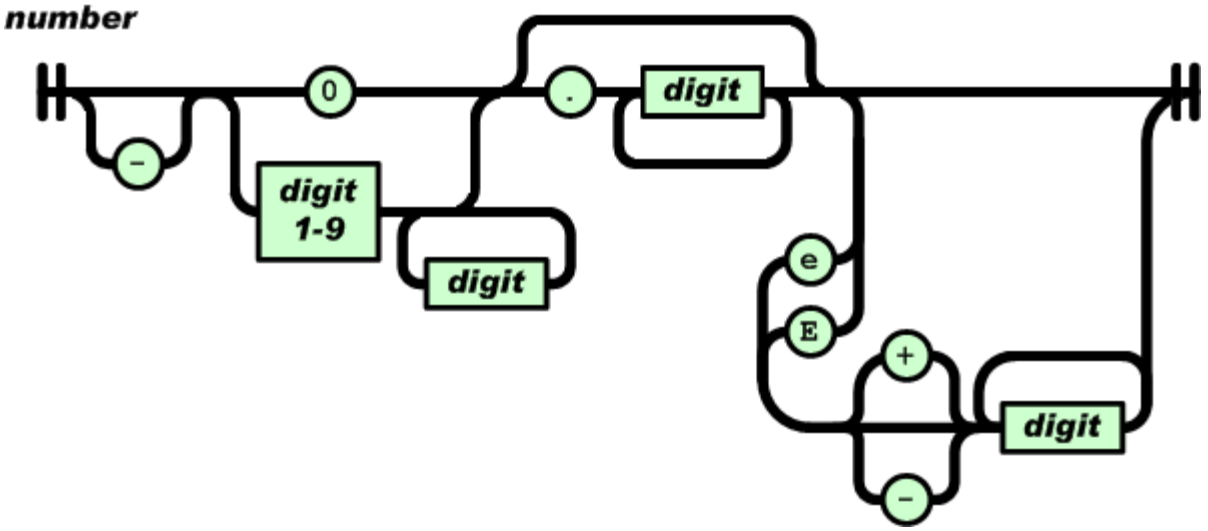
JSON – Basic Data Types

- string – sequence of zero or more Unicode characters, wrapped in double quotes
  - Backslash escaping

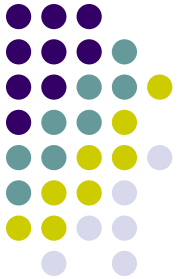


JSON – Basic Data Types

- number – like a C or Java number
  - Octal and hexadecimal formats are not used



JSON Example



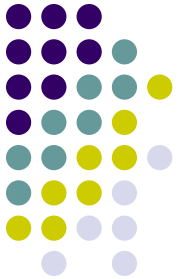
```
{
    "firstName": "John",
    "lastName": "Smith",
    "age": 25,
    "address": {
        "streetAddress": "21 2nd Street",
        "city": "New York",
        "state": "NY",
        "postalCode": 10021
    },
    "phoneNumbers": [
        {
            "type": "home",
            "number": "212 555-1234"
        },
        {
            "type": "fax",
            "number": "646 555-4567"
        }
    ]
}
```

name/value pair

array

object

JSON Schema

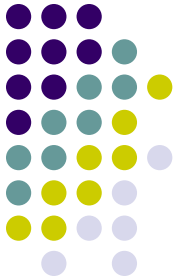


- JSON-based format
- Defines the structure of JSON data for validation and/or documentation
- Based on concepts from DTD, XML Schema, RELAX NG, …
- …but:
  - Is JSON-based
    - The same serialization/deserialization tools can be used for schema and data
  - Is self-describing

XML: DTD vs. XML Schema

http://json-schema.org/

JSON Schema Example



```
{
    "id": 1,
    "name": "Foo",
    "price": 123,
    "tags": [ "Bar", "Eek" ],
    "stock": {
        "warehouse": 300,
        "retail": 20
    }
}
```

How to describe the allowed structure of these data?

```
{
    "title": "Product",
    "type": "object",
    "properties": {
        "id": {
            "type": "number",
            "description": "Product identifier"
        },
        "name": {
            "type": "string",
            "description": "Name of the product"
        },
        "price": {
            "type": "number",
            "minimum": 0
        },
        "tags": {
            "type": "array",
            "items": {
                "type": "string"
            }
        },
        "stock": {
            "type": "object",
            "properties": {
                "warehouse": {
                    "type": "number"
                },
                "retail": {
                    "type": "number"
                } } } }
    "required": ["id", "name", "price"]
}
```

JSON Schema – Principles

- JSON schema is a JSON document
  - Must be a single JSON object
- Properties of the object = keywords
  - Defined in the specification
- JSON schema may contain other properties which are not keywords
- Empty schema = schema (object) with no properties

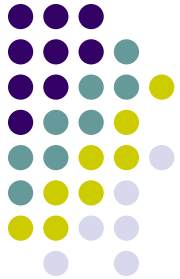
root schema with no subschemas

```
{
    "title": "root"
}
```

subschemas

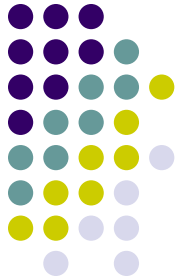
```
{
    "title": "root",
    "otherSchema": {
        "title": "nested",
        "anotherSchema": {
            "title": "alsoNested"
        }
    }
}
```

JSON Schema Primitive Types



- Correspond to basic data types
  - boolean – JSON Boolean
  - integer – JSON number without a fraction or exponent part
  - number – any JSON number
    - Includes integer
  - null – JSON null value
  - string – JSON string
  - array – JSON array
  - object – JSON object

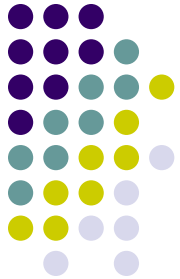
JSON Value Equality



- Two JSON values are said to be **equal** if:
  - both are nulls or
  - both are booleans / strings / numbers and have the same value or
  - both are arrays and
    - have the same number of items and
    - items at the same index are equal according to this definition or
  - both are objects and
    - have the same set of property names and
    - values for a same property name are equal according to this definition.

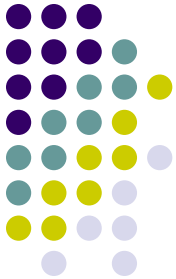
XML: XPath equivalence of collections

Metadata Keywords



- title, description
  - arbitrary strings
  - can be used anywhere
  - title is expected to be short, description may be longer
- default
  - a default JSON value associated with a particular (sub)schema

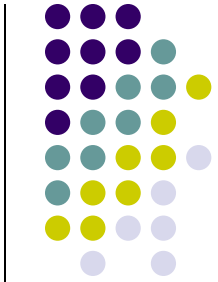
Keywords for Any Instance Type



XML: simple data types

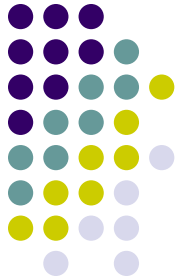
- enum
  - an array of allowed values
- type
  - an array of allowed types
- allOf
  - an array of JSON schemas
  - against all of them an instance should be valid
- anyOf
  - an array of JSON schemas
  - against at least one of them an instance should be valid
- not
  - negation
- definitions
  - location for schema authors to inline other JSON schemas

Keywords for Numeric Instances



- multipleOf
  - an instance is a multiple of the value
- maximum / minimum
  - an instance is lower / greater than or equal to the value
- exclusiveMaximum / exclusiveMinimum = true
  - an instance is lower / greater than the value of "maximum" / "minimum"

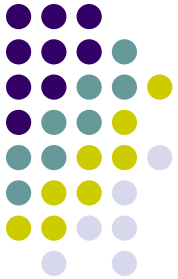
Keywords for Strings



- minLength / maxLength
  - the length of an instance is greater / lower than or equal to the value
- pattern
  - an instance is considered valid if the regular expression matches the instance successfully
  - ECMA 262 regular expression dialect

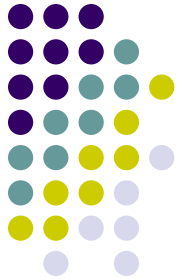
http://www.ecma-international.org/publications/standards/Ecma-262.htm

Keywords for Arrays



- items
  - an object = an array of objects of this type
  - an array of objects = an array of objects of these types and positions
- maxItems / minItems
  - the size of an item is less / greater than or equal to the value
- uniqueItems = true
  - all items of an instance are unique
- additionalItems
  - only if keyword "items" represents an array of objects
    - otherwise ignored
  - Boolean = other types of objects are (not) allowed
  - an object = this type of object is also allowed

Validation Keywords for Objects



- properties
  - an object
  - each value of this object must be an object representing an (optional) property
- maxProperties / minProperties
  - the number of properties is less / greater than or equal to the value
- required
  - an array of required properties
- additionalProperties
  - Boolean = other types of properties are (not) allowed
  - an object = this type of property is also allowed
- patternProperties
  - an object
  - each property name of this object should be a valid regular expression describing a set of properties

similar to arrays

An Example Step-by-Step

```
{
    "id": 1,
    "name": "A green door",
    "price": 12.50,
    "tags": ["home", "green"]
}
```

- What is id?
- Is name required?
- Can price be 0?
- Are all tags strings?

An Example Step-by-Step

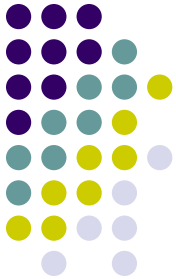
To Start With…

this schema is written according to the draft v4 specification

```
{
    "$schema": "http://json-schema.org/draft-04/schema#",
    "title": "Product",
    "description": "A product from Acme's catalog",
    "type": "object"
}
```

An Example Step-by-Step

What is id?



```
{
    "$schema": "http://json-schema.org/draft-04/schema#",
    "title": "Product",
    "description": "A product from Acme's catalog",
    "type": "object",
    "properties": {
        "id": {
            "description": "The unique identifier for a product",
            "type": "integer"
        }
    },
    "required": ["id"]
}
```

- ID is a required property of type integer

An Example Step-by-Step

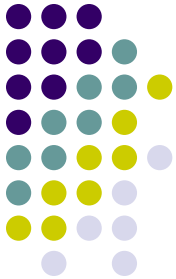
Is name required?

```
{
    "$schema": "http://json-schema.org/draft-04/schema#",
    "title": "Product",
    "description": "A product from Acme's catalog",
    "type": "object",
    "properties": {
        "id": {
            "description": "The unique identifier for a product",
            "type": "integer"
        },
            "name": {
                "description": "Name of the product",
                "type": "string"
            }
      },
      "required": ["id", "name"]
}
```

- Name is a required string

An Example Step-by-Step

Can price be 0?

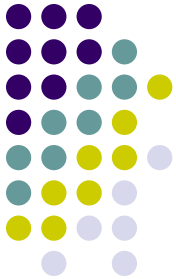


```
{
    "$schema": "http://json-schema.org/draft-04/schema#",
    "title": "Product",
    "description": "A product from Acme's catalog",
    "type": "object",
    "properties": {
        "id": {
            "description": "The unique identifier for a product",
            "type": "integer"
        },
        "name": {
            "description": "Name of the product",
            "type": "string"
        },
            "price": {
                "type": "number",
                "minimum": 0,
                "exclusiveMinimum": true
            }
        },
        "required": ["id", "name", "price"]
}
```

- Price is a required number greater than zero

An Example Step-by-Step

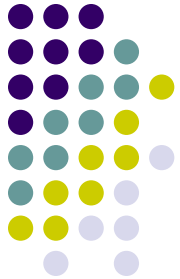
Are all tags strings?



```
{
   "$schema": "http://json-schema.org/draft-04/schema#",
   "title": "Product",
   "description": "A product from Acme's catalog",
   "type": "object",
   "properties": {
       "id": {
           "description": "The unique identifier for a product",
           "type": "integer"
       },
       "name": {
           "description": "Name of the product",
           "type": "string"
       },
       "price": {
           "type": "number",
           "minimum": 0,
           "exclusiveMinimum": true
       },
            "tags": {
                "type": "array",
                "items": {
                    "type": "string"
                },
                "minItems": 1,
                "uniqueItems": true
            }
     },
     "required": ["id", "name", "price"]
}
```

- Tags form an array of at least one string with unique values

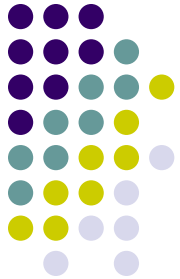
JSON Software



- JSON parsers
- JSON Schema validators
  - JavaScript, Java, Python, Ruby, PHP, .NET, C, Haskell, …
- JSON Schema generators
  - http://www.jsonschema.net/
- XML-to-JSON transformers
- …

http://json-schema.org/implementations.html

JSON Hyper-Schema



- How JSON Schema can be used to define hyperlinks
- Defines keywords for the JSON Schema that allow JSON data to:
  - be understood as hyper-text
  - be interpreted as rich multimedia documents

http://json-schema.org/latest/json-schema-hypermedia.html

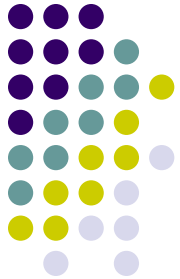
```
{
    "title": "Written Article",
    "type": "object",
    "properties": {
        "id": {
            "title": "Article Identifier",
            "type": "number"
        },
        "title": {
            "title": "Article Title",
            "type": "string"
        },
        "authorId": {
            "type": "integer"
        },
        "imgData": {
            "title": "Article Illustration (small)",
            "type": "string",
            "media": {
                "binaryEncoding": "base64",
                "type": "image/png"
            }
        }
    },
    "required" : ["id", "title", "authorId"],
    "links": [
        {
            "rel": "full",
            "href": "{id}"
        },
        {
            "rel": "author",
            "href": "/user?id={authorId}"
        }
    ]
}
```

```
{
    "id": 15,
    "title": "Example data",
    "authorId": 105,
    "imgData": "iVBORw...kJggg=="
}
```

name of relation to the target

target URI

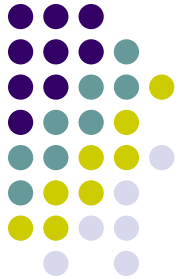
JsonML (JSON Markup Language)



- An application of JSON
- Lightweight markup language
  - Markup language with simple syntax
- Provides a compact format for transporting / processing XML-based markup as JSON
  - “Lossless” conversion back to original form
- Allows manipulation of XML data without the overhead of an XML parser
  - Using tools for JSON (typically in JavaScript)
  - Exploited mainly in AJAX
    - see later
- We can find:
  - An XSLT script for XML-to-JsonML transformation
  - A JavaScript for JsonML-to-DOM transformation

http://www.jsonml.org/

JsonML



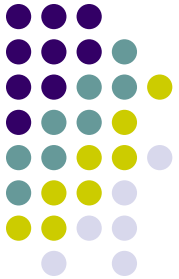
- JSON vs. XML:
  - JSON arrays ↔ XML elements
  - JSON objects ↔ attributes
  - JSON strings ↔ text nodes
- Notes:
  - Comments are not supported
  - Namespaces are “supported” only in some implementations
    - Namespace declaration considered as attributes
    - Qualified names considered as names
- Result:
  - A more compact representation

```
element
    = '[' tag-name ',' attributes ',' element-list ']'
    | '[' tag-name ',' attributes ']'
    | '[' tag-name ',' element-list ']'
    | '[' tag-name ']'
    | json-string
    ;
tag-name
    = json-string
    ;
attributes
    = '{' attribute-list '}'
    | '{' '}'
    ;
attribute-list
    = attribute ',' attribute-list
    | attribute
    ;
attribute
    = attribute-name ':' attribute-value
    ;
attribute-name
    = json-string
    ;
attribute-value
    = json-string
    ;
element-list
    = element ',' element-list
    | element
    ;
```

JsonML grammar

JsonML Example

XHTML Unordered List



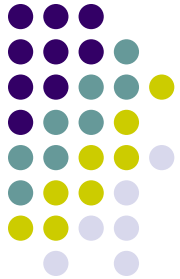
```
[
    "ul",
    { style : "list-style-type:none" },
    [ "li", "First item" ],
    [ "li", "Second item" ],
    [ "li", "Third item" ],
];
```

JsonML
Bigger Example

```
<table class="maintable">
  <tr class="odd">
    <th>Situation</th>
    <th>Result</th>
  </tr>
  <tr class="even">
    <td><a href="driving.html"
           title="Driving"
      >Driving</a></td>
    <td>Busy</td>
  </tr>
  ...
</table>
```

```
["table",
 {"class":"maintable"},
 "\n",
 ["tr",
  {"class":"odd"},
  "\n",
  ["th",
   "Situation"],
  "\n",
  ["th",
   "Result"],
  "\n"],
 "\n",
 ["tr",
  {"class":"even"},
  "\n",
  ["td",
   ["a",
    {"href":"driving.html",
     "title":"Driving"},
    "Driving"]],
  "\n",
  ["td",
   "Busy"],
  "\n"],
 ]
```

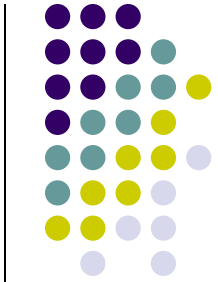
AJAX (Asynchronous JavaScript and XML)



- Idea: Web applications can send / retrieve data to / from a server asynchronously
  - At the background
  - Without interfering with the display and behavior of the existing page
- Typically using `XMLHttpRequest` object
  - Asynchronous request for data from web server
    - Must be the same that served the original web page
  - Response: used for altering the current web page without re-load
- We do not need to use XML format
  - AJAJ – Asynchronous JavaScript and JSON
- Example: Google Mail, Google Maps, …

Jesse James Garrett – Ajax: A New Approach to Web Applications. 2005

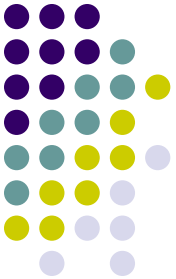
`XMLHttpRequest` object



- Standard API for transferring data between a client and a server
- Supports any text format
  - The name is just for compatibility
  - Typically: **XML**, HTML, **JSON**, plain text
- Both HTTP and HTTPS requests
  - Some applications support also other protocols

http://www.w3.org/TR/XMLHttpRequest/

XMLHttpRequest Examples



```
function log(message) {
  var client = new XMLHttpRequest();
  client.open("POST", "/log");
  client.setRequestHeader("Content-Type", "text/plain;charset=UTF-8");
  client.send(message);
}
```

sets request method + URL (+ other parameters)

sends the request

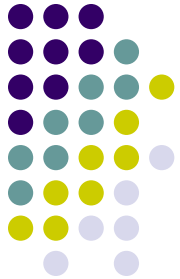
- to log a message to the server

setting a handler

```
function fetchStatus(address) {
  var client = new XMLHttpRequest();
  client.onreadystatechange = function() {
    // in case of network errors this might not give reliable results
    if(this.readyState == this.DONE)
      returnStatus(this.status);
  }
  client.open("HEAD", address);
  client.send();
}
```

- to check the status of a document on the server

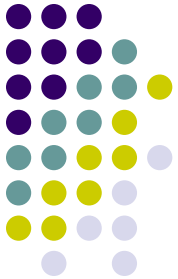
BSON (Binary JSON)



- Binary-encoded serialization of JSON documents
  - Allows embedding of documents, arrays, JSON simple data types + other types (e.g., date)
- Primary data representation in MongoDB database
  - Document NoSQL database
    - Documents described in JSON
  - Data storage and network transfer format

http://www.mongodb.com/ http://bsonspec.org/

BSON Example



```
{"hello": "world"}
```

→

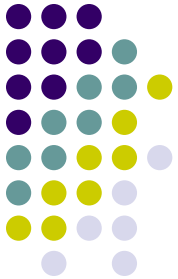
```
"\x16\x00\x00\x00\x02hello\x00
 \x06\x00\x00\x00world\x00\x00"
```

```
{"BSON": ["awesome",
5.05, 1986]}
```

→

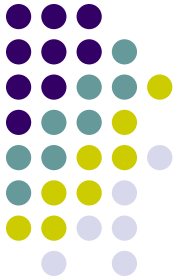
```
"\x31\x00\x00\x00\x04BSON\x00\x26\x00
 \x00\x00\x020\x00\x08\x00\x00
 \x00awesome\x00\x011\x00\x33\x33\x33
\x33\x33\x33
 \x14\x40\x102\x00\xc2\x07\x00\x00
 \x00\x00"
```

BSON Basic Types



- `byte` – 1 byte (8-bits)
- `int32` – 4 bytes (32-bit signed integer)
- `int64` – 8 bytes (64-bit signed integer)
- `double` – 8 bytes (64-bit IEEE 754 floating point)

BSON Grammar



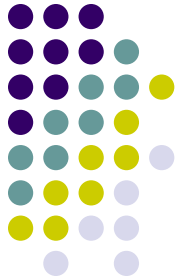
```
document ::= int32 e_list "\x00"
```

- BSON document
- `int32` = total number of bytes

```
e_list ::= element e_list | ""
```

- Sequence of elements

BSON Grammar



```
element ::= "\x01" e_name double
   | "\x02" e_name string
   | "\x03" e_name document
   | "\x04" e_name document
   | "\x05" e_name binary
   | …
```

- Floating point
- UTF-8 string
- Embedded document
- Array
- Binary data
- …

```
e_name ::= cstring
cstring ::= (byte*) "\x00"
```

- Key name

```
string ::= int32 (byte*) "\x00"
```

- String = `int32` bytes

And so on…

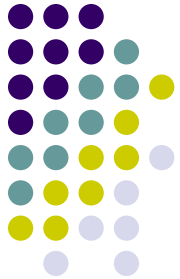
JSONiq – the JSON Query Language

- Query and functional programming language
- For declarative querying and transforming of hierarchical data formats…
  - JSON, XML
- …as well as unstructured textual data
- Based on XQuery
  - Core expressions, operations on atomic types, …
- Two syntaxes:
  - (pure/core) JSONiq syntax
    - Extended with XML support
  - XQuery syntax extended with JSON support
- Superset of JSON
  - Each JSON document is a JSONiq program

XML: similar to XQuery

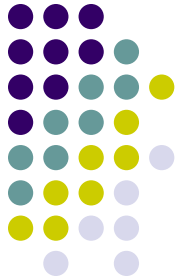
http://www.jsoniq.org/

JSONiq – Basics



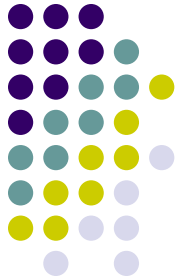
- Aim: to extract and transform data from JSON documents
  - or any data that can be viewed as JSON data
- Major expression: SQL-like FLWOR expression from XQuery
  - FOR, LET, WHERE, ORDER BY, RETURN
  - Plus other operations
    - Grouping, windowing, …
- Navigational syntax to extract data
- Constructs can be nested

JSONiq Syntaxes



- JSONiq syntax
  - Not concerned with XML features
    - Mixed content, ordered children, difference between attributes and elements, namespaces and QNames, …
- XQuery syntax
  - Allows processing XML and JSON natively and with a single language
  - More complex
    - Has to follow rules of both languages (and especially more complex XQuery)

JSONiq Data Model (JDM)



- Extension of XQuery and XPath Data Model
- Tree-structured model
  - JSON objects
  - JSON arrays
  - All kinds of XML nodes
  - Atomic values
    - As defined in XML Schema specification
    - Include JSON simple types

Example 1. Join

collection("users")

```
{
"name" : "Sarah",
"age" : 13,
"gender" : "female",
"friends" : [ "Jim",
"Mary", "Jennifer"]
},
{
"name" : "Jim",
"age" : 13,
"gender" : "male",
"friends" : [ "Sarah" ]
}
```

```
{|
for $sarah in collection("users"),
    $friend in collection("users")
where
    $sarah.name eq "Sarah"
    and
    (some $name in $sarah.friends[]
     satisfies $friend.name eq $name)
return $friend
|}
```

```
{ "name" : "Jim", "age" : 13, "gender"
: "male", "friends" : [ "Sarah" ] }
```

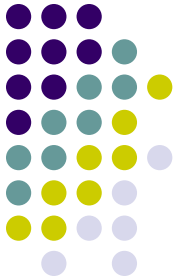
- Join on Sarah's friend list to return the Object representing each of her friends

Example 1. Join with Predicate

```
{|
for $sarah in collection("users"),
    $friend in collection("users")
where
    $sarah.name eq "Sarah"
    and
    (some $name in $sarah.friends[]
     satisfies $friend.name eq $name)
return $friend
|}
```

```
{|
let $sarah := collection("users")[$$.name eq "Sarah"]
for $friend in $sarah.friends[]
return collection("users")[$$.name eq $friend]
|}
```

Example 2. Grouping



collection("sales")

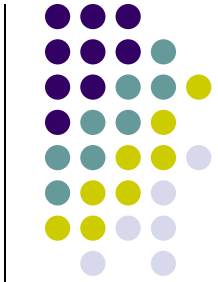
```
{ "product" : "broiler", "store number" : 1, "quantity" : 20 },
{ "product" : "toaster", "store number" : 2, "quantity" : 100 },
{ "product" : "toaster", "store number" : 2, "quantity" : 50 },
{ "product" : "toaster", "store number" : 3, "quantity" : 50 },
{ "product" : "blender", "store number" : 3, "quantity" : 100 },
{ "product" : "blender", "store number" : 3, "quantity" : 150 },
{ "product" : "socks", "store number" : 1, "quantity" : 500 },
{ "product" : "socks", "store number" : 2, "quantity" : 10 },
{ "product" : "shirt", "store number" : 3, "quantity" : 10 },
…
```

```
{|
for $sales in collection("sales")
let $pname := $sales.product
group by $pname
return { $pname : sum($sales.quantity) }
|}
```

```
{
  "toaster" : 200,
  "blender" : 250,
  "shirt" : 10,
  "socks" : 510,
  "broiler" : 20
}
```

- Grouping sales by product, across stores

Example 3. More Complex Grouping – Data



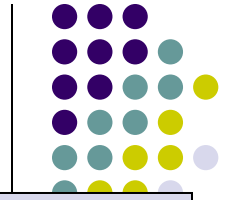
collection("stores")

```
{ "store number" : 1, "state" : "CA" },
{ "store number" : 2, "state" : "CA" },
{ "store number" : 3, "state" : "MA" },
{ "store number" : 4, "state" : "MA" }
```

collection("products")

```
{ "name" : "broiler", "category" : kitchen", "price" : 100, "cost" : 70 },
{ "name" : "toaster", "category" : "kitchen", "price" : 30, "cost" : 10 },
{ "name" : "blender", "category" : "kitchen", "price" : 50, "cost" : 25 },
{ "name" : "socks", "category" : "clothes", "price" : 5, "cost" : 2 },
{ "name" : "shirt", "category" : "clothes", "price" : 10, "cost" : 3 }
```

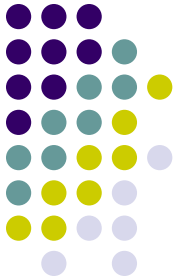
Example 3. More Complex Grouping – Query



```
{|
for $store in collection("stores")
let $state := $store.state
group by $state
return {
  $state : {|
    for $product in collection("products")
    let $category := $product.category
    group by $category
    return {
      $category : {|
        for $sales in collection("sales")
        where (some $s in $store
               satisfies $sales."store number" eq $s."store number")
          and (some $p in $product
               satisfies $sales.product eq $p.name)
        let $pname := $sales.product
        group by $pname
        return { $pname : sum( $sales.quantity ) }
        |}
      }
    |}
  }
|}
```

```
{
  "MA" :
    { "clothes" :
        { "shirt" : 10 },
      "kitchen" :
        { "toaster" : 50,
          "blender" : 250 } },
  "CA" :
    { "clothes" :
        { "socks" : 510 },
      "kitchen" :
        { "toaster" : 150,
          "broiler" : 20 } }
}
```

Example 4. JSON-to-JSON Transformation – Data

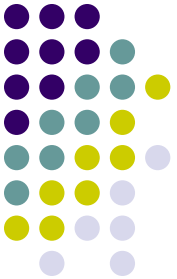


collection("satellites")

```
{
  "creator" : "Satellites plugin version 0.6.4",
  "satellites" : {
    "AAU CUBESAT" : {
      "tle1" : "1 27846U 03031G 10322.04074654 .00000056 00000-0 45693-4 0 8768",
      "visible" : false
      },
    "AJISAI (EGS)" : {
      "tle1" : "1 16908U 86061A 10321.84797408 -.00000083 00000-0 10000-3 0 3696",
      "visible" : true
      },
    "AKARI (ASTRO-F)" : {
      "tle1" : "1 28939U 06005A 10321.96319841 .00000176 00000-0 48808-4 0 4294",
      "visible" : true
      }
}
```

- We want to return a summary

Example 4. JSON-to-JSON Transformation – Query



```
{|
let $sats := collection("satellites").satellites
return {
  "visible" : [
    for $sat in keys($sats)
    where $sats.$sat.visible
    return $sat
  ],
"invisible" : [
    for $sat in keys($sats)
    where not $sats.$sat.visible
    return $sat
  ]
|}
```

```
{
  "visible" : [ "AJISAI (EGS)", "AKARI (ASTRO-F)" ],
  "invisible" : [ "AAU CUBESAT" ]
}
```

Example 5. JSON Updates

collection("users")

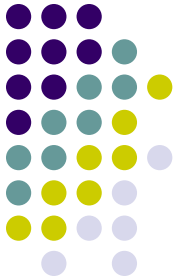
```
{
  "name" : "Deadbeat Jim",
  "address" : "1 E 161st St, Bronx, NY 10451",
  "risk tolerance" : "high"
}
```

- We want to add adds **"status" : "credit card declined"** to the user's record

```
{|
let $dbj := collection("users")[ $$.name = "Deadbeat Jim" ]
return insert { "status" : "credit card declined" } into $dbj
|}
```

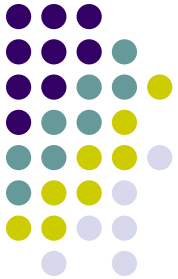
```
{
  "name" : "Deadbeat Jim",
  "address" : "1 E 161st St, Bronx, NY 10451",
  "status" : "credit card declined",
  "risk tolerance" : "high"
}
```

JSONiq Future Work



- Aim: to finish standardization of:
  - JSONiq full-text support
    - Based on XQuery 1.0 and XPath 2.0 Full-Text
  - JSONiq update support
    - Based on XQuery Update Facility
  - JSONiq scripting support
    - XQuery Scripting 1.0
      - Extension of XQuery to serve as a scripting language

References



- JSON: http://www.json.org/
- RFC 4627: http://tools.ietf.org/html/rfc4627
- JSON Schema: http://json-schema.org/
- JSON Hyper-Schema: http://json-schema.org/latest/json-schema-hypermedia.html
- JsonML: http://www.jsonml.org/
- Jesse James Garrett – Ajax: A New Approach to Web Applications: http://web.archive.org/web/20080702075113/http://www.adaptivepath.com/ideas/essays/archives/000385.php
- XMLHttpRequest W3C Specification: http://www.w3.org/TR/XMLHttpRequest/
- BSON: http://bsonspec.org/
- JSONiq: http://www.jsoniq.org/
- JSONiq Use Cases: http://www.jsoniq.org/docs/JSONiq-usecases/pdf/JSONiq_-_the_SQL_of_NoSQL-1.0-JSONiq_Use_Cases-en-US.pdf