XML Technologies and Applications

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I: Introduction and XML Basics

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Outline

- Introduction
- XML Basics
- XML Structural Constraint Specification
  - Document Type Definitions (DTDs)
  - XML Schema
- XML/Database Mappings
- XML Parsing APIs
  - Simple API for XML (SAX)
  - Document Object Model (DOM)
- XML Querying and Transformation
  - XPath
  - XQuery
  - XSLT
- XML Applications

Introduction

- XML: A W3C standard to complement HTML
- Two facets of XML: document-centric and data-centric
- Motivation
  - HTML describes presentation
  - XML describes content
- User defined tags to markup “content”
- Text based format.
- Ideal as “Data Interchange” format.
- Key technology for “distributed” applications.
- All major database products have been retrofitted with facilities to store and construct XML documents.
- XML is closely related to object-oriented and so-called *semi-structured* data.

Semistructured Data

An HTML document (student list) to be displayed on the Web

```
<dt>Name: John Doe
  <dd>Id: s111111111
  <dd>Address:
    <ul>
      <li>Number: 123</li>
      <li>Street: Main</li>
    </ul>
</dt>
<dt>Name: Joe Public
   <dd>Id: s222222222
    … … … …
</dt>
```

HTML does not distinguish between attributes and values

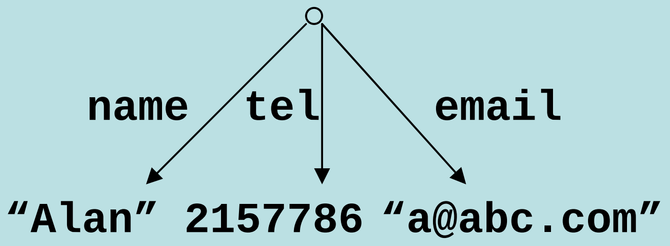
Semistructured Data (cont'd.)

- To make the previous student list suitable for machine consumption on the Web, it should have the following characteristics
  - Be *object-like*
  - Be *schemaless* (not guaranteed to conform exactly to any schema, but different objects have some commonality among themselves.
  - Be *self-describing* (some schema-like information, like attribute names, is part of data itself)
- Data with these characteristics are referred to as *semistructured.*

Semi-structured Data Model

- Set of label-value pairs.

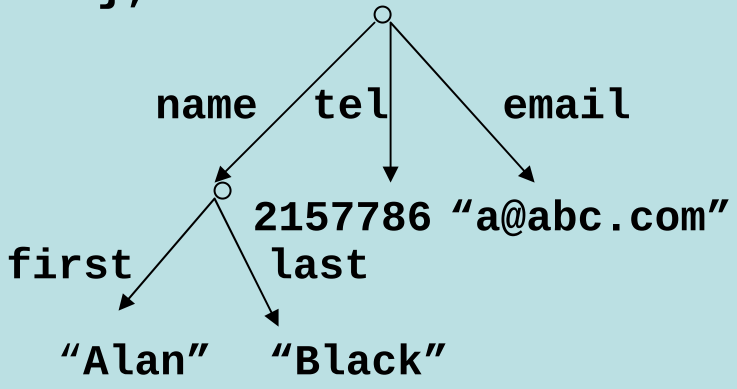
```
{name: "Alan",
 tel: 2157786,
 email: “a@abc.com”
}
```



Graph Model: Nodes represent objects connected by labeled edges to values

- The values themselves may be structures

```
{name: {first: “Alan”, last: “Black”},
 tel: 2157786,
 email: “a@abc.com”
}
```



Semi-structured Data Model

- Duplicate labels allowed

```
{name: "Alan", tel: 2157786, tel: 2498762"}
```

- The syntax is easily generalized to describe sets of objects

```
{person: {name: “Alan”,tel: 2157786,email: “a@abc.com”}
 person: {name: “Sara”,tel: 2136877,email: “sara@abc.com”}
 person: {name: “Fred”,tel: 7786312,email: “fred@abc.com”}
}
```

- All objects within a set need not have the same structure

```
{person:{name: “Alan”,tel: 2157786,email: “a@abc.com”},
 person:{name: {first: “Sara”,last: “Black”},email: “s@abc.com”},
 person:{name: “Fred”, tel: 7786312, height: 168}
}
```

Semi-structured Data Model

- Relational Data is easily represented

```
{r1: {row: {a: a1, b: b1, c: c1},
      {row: {a: a2, b: b2, c: c2}},
 r2: {row: {c: c2, d: d2},
       row: {c: c3, d: d3},
       row: {c: c4, d: d4}}
 }
```

- Object-oriented data is also naturally represented (each node has a unique object id, either explicitly mentioned or system generated)

```
{person: &o1{name: “Mary”, age: 45,
               child: &o2, child: &o3},
 person: &o2{name: “John”, age: 17,
               relatives: {mother: &o1, sister: &o3}},
 person: &o3{name: “Jane”, country: “Canada”, mother: &o1}
 }
```

Semi-structured Data Model

- Formal syntax for semi-structured data model

```
<ssd-expr> ::== <value> | oid <value> | oid
<value>    ::== atomicvalue | <complexvalue>
<complexvalue> ::==
   { label:<ssd-expr>, ..., label:<ssd-expr> }
```

- An oid value is said to be DEFINED if it appears before a value; otherwise it is said to be USED
- An ssd-expression is CONSISTENT if
  - An oid is defined at most once and
  - If an oid is used, it must also be defined.
- A flexible and powerful data model that is capable of representing data that does not have to follow the strict rules of databases.

What is Self-describing Data?

Non-self-describing (relational, object-oriented):

Data part:

```
(#12345,  [“Students”,   {[“John”, s111111111, [123,”Main St”]],
                          [“Joe”, s222222222, [321, “Pine St”]] }
          ] )
```

Schema part:

```
PersonList[ ListName: String,
            Contents: [ Name: String,
                        Id: String,
                        Address: [Number: Integer,  Street: String]  ]
          ]
```

What is Self-Describing Data? (contd.)

- Self-describing:
  - Attribute names embedded in the data itself, *but are distinguished* from values
  - Doesn't need schema to figure out what is what (but schema might be useful nonetheless)

```
(#12345,
    [ListName: "Students",
      Contents:  { [ Name: "John Doe",
                     Id:  "s111111111",
                     Address: [Number: 123, Street: "Main St."] ] ,
                   [Name: "Joe Public",
                    Id:  "s222222222",
                    Address: [Number: 321, Street: "Pine St."] ]  }
    ] )
```

XML – The De Facto Standard for Semi-structured Data

- XML: eXtensible Markup Language
  - Suitable for semi-structured data and has become a standard
  - Used to describe content rather than presentation
  - Differs from HTML in following ways
    - New tags may be defined at will by the author of the document (extensible)
    - No semantics behind tags. For instance, HTML's <table>...</table> means: render contents as a table; in XML: doesn't mean anything special.
    - Structures may be nested arbitrarily
    - XML document may contain an optional schema that describes its structure
    - Intolerant to bugs; Browsers will render buggy HTML pages but XML processors will reject ill-formed XML documents.

XML Syntax

XML Elements

element: piece of text bounded by user-defined matching tags:

```
 <person>
    <name>Alan</name>
    <age>42</age>
    <email>agb@abc.com</email>
  </person>
```

Note:

- Element includes the start and end tag
- No quotation marks around strings; XML treats all data as text. This is referred to as PCDATA (Parsed Character Data).
- Empty elements:

  `<married></married>` can be abbreviated to **`<married/>`**

XML Syntax - Continued

Collections are expressed using repeated structures.

Ex. The collection of all persons on the 4th floor:

```
<table>
  <description>People on the 4th floor</description>
  <people>
    <person>
      <name>Alan</name><age>42</age<<email>agb@abc.com</email>
    </person>
    <person>
      <name>Patsy</name><age>36</age><email>ptn@abc.com</email>
    </person>
    <person>
      <name>Ryan</name><age>58</age><email>rgz@abc.com</email>
    </person>
  </people>
</table>
```

XML Syntax - Continued

XML Attributes

- Attributes define some properties of elements
- Expressed as a name-value pairs

```
<product>
  <name language="French">trompette six trous</name>
  <price currency="Euro">420.12</price>
  <address format="XLB56" language="French">
    <street>31 rue Croix-Bosset</street>
    <zip>92310</zip>
    <city>Sevres</city>
    <country>France</country>
  </address>
</product>
```

- As with tags, user may define any number of attributes
- Attribute values must be enclosed within quotation marks.

XML Syntax - Continued

Attributes vs Elements

- A given attribute can occur only once within a tag; Its value is always a string
- On the other hand tags defining elements/sub-elements can repeat any number of times and their values may be string data or sub-elements
- Same data may be encoded using attributes or elements or a combination of the two

```
<person name="Alan" age="42">
    <email>agb@abc.com</email>
</person>
```

or

```
<person name="Alan">
 <age>42</age>
 <email>agb@abc.com</email>
</person>
```

XML Syntax - Continued

XML References

- Use `id` attribute to define a reference (similar to oids)
- Use `idref` attribute (in an empty element) to refer to a previously defined reference.

```
<state id="s2">              -- defines an id or a reference
    <scode>NE</scode>
    <sname>Nevada</sname>
  </state>

 <city id="c2">
  <ccode>CCN</ccode>
  <cname>Carson City</cname>
  <state-of idref="s2"/>    -- refers to object called s2;
                            -- this is an empty element
 </city>
```

XML Syntax - Continued

Mixing Elements and Text

- XML allows us to mix PCDATA and sub-elements within an element.

```
<person>
  This is my best friend
  <name>Alan</name>
  <age>42</age>
  I am not sure of the following email
  <email>agb@abc.com</email>
</person>
```

- This seems un-natural from a database perspective, but from a document perspective, this is quite natural!

XML Syntax - Continued

Order

- The semi-structured data model is based on unordered collections, whereas XML is ordered. The following two pieces of semi-structured data are equivalent:

```
person: {fname: "John", lname: "Smith:}
person: {lname: "Smith", fname: "John"}
```

  but the following two XML data are not:

```
<person><fname>John</fname><lname>Smith</lname></person>
<person><lname>Smith></lname><fname>John</fname></person>
```

- To make matters worse, attributes are NOT ordered in XML; Following two are equivalent:

```
<person fname="John" lname="Smith"/>
<person lname="Smith" fname="John"/>
```

XML Syntax - Continued

Other XML Constructs

- Comments:

```
<!-- this is a comment -->
```

- Processing Instruction (PI):

```
<?xml version="1.0"?>
<?xml-stylesheet type="text/xsl" href="classes.xsl"?>
```

Such instructions are passed on to applications that process XML files.

- CDATA (Character Data): used to write escape blocks containing text that otherwise would be considered markup:

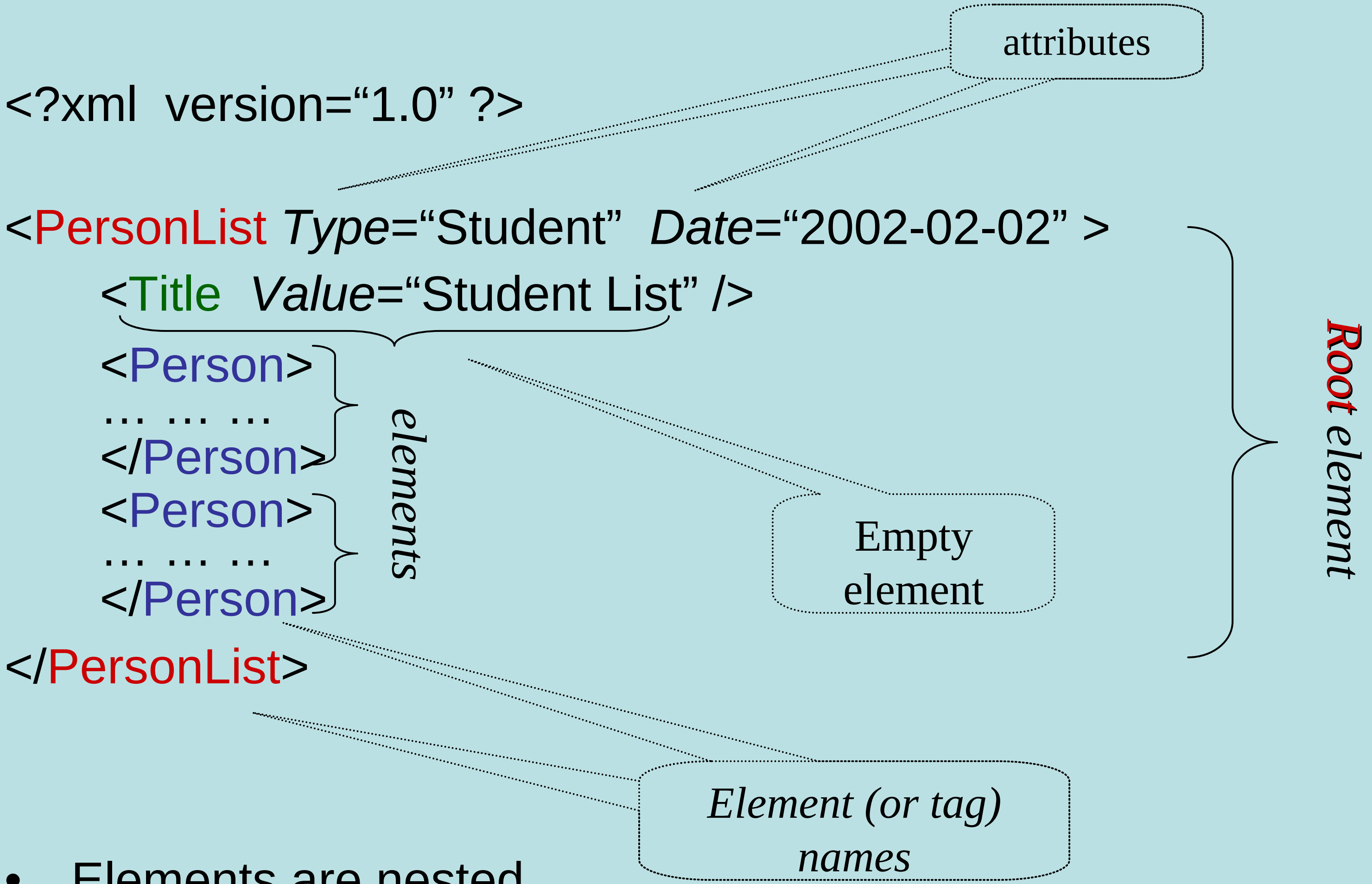
```
<![CDATA[<start>this is not an element</start>]]>
```

- Entities: **`&lt`** stands for **<**

Well-Formed XML Documents

- An XML document is *well-formed* if
  - Tags are syntactically correct
  - Every tag has an end tag
  - Tags are properly nested
  - There is a root tag
  - A start tag does not have two occurrences of the same attribute
- An XML document must be well-formed before it can be processed.
- A well-formed XML document will parse into a node-labeled tree

Terminology

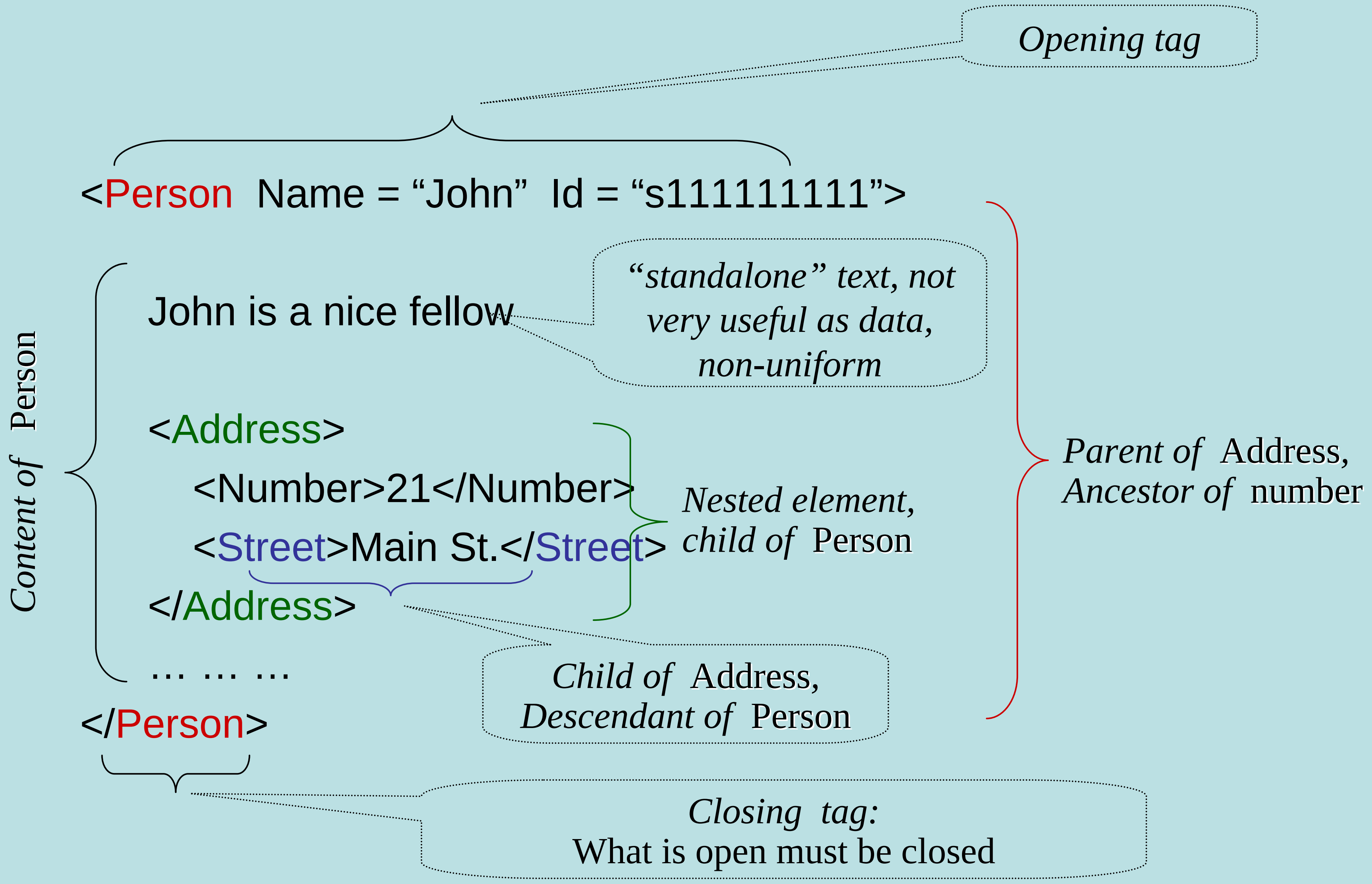


```
<?xml  version="1.0" ?>

<PersonList Type="Student"  Date="2002-02-02" >
      <Title  Value="Student List" />
      <Person>
      … … …
      </Person>
      <Person>
      … … …
      </Person>
</PersonList>
```

- Elements are nested
- Root element contains all others

More Terminology



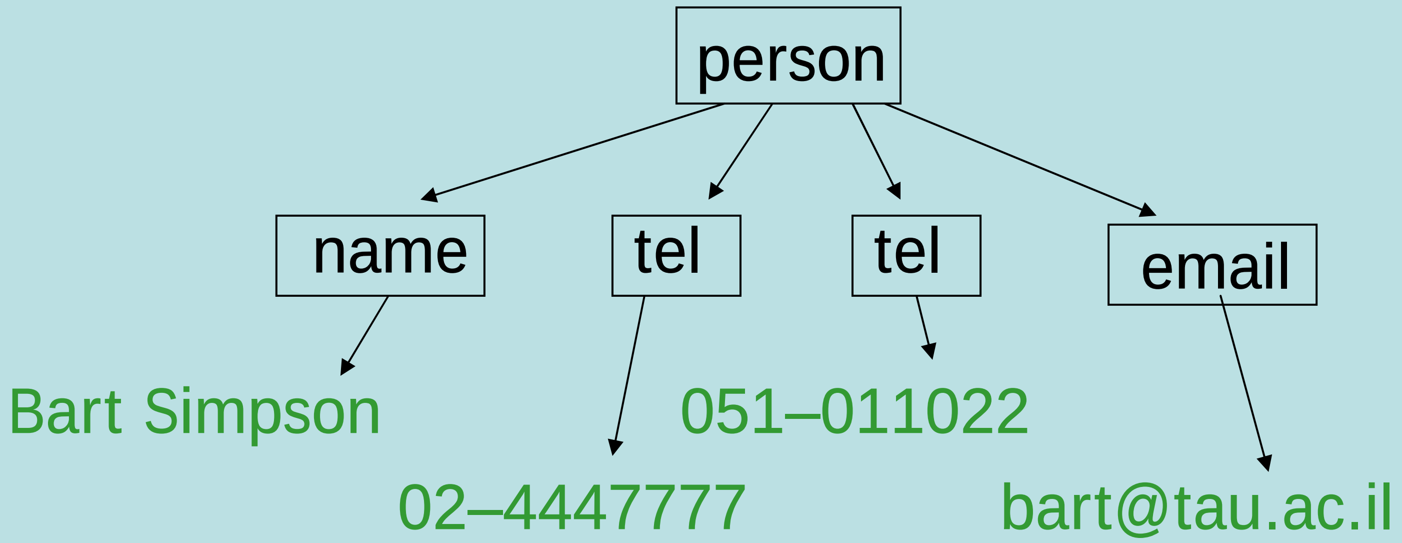
```
<Person  Name = “John”  Id = “s111111111”>

    John is a nice fellow

    <Address>
       <Number>21</Number>
       <Street>Main St.</Street>
    </Address>
    … … …
</Person>
```

Opening tag
“standalone” text, not very useful as data, non-uniform
Parent of Address, Ancestor of number
Nested element, child of Person
Content of Person
Child of Address, Descendant of Person
Closing tag: What is open must be closed

XML Data Model



- Document Object Model (DOM) – DOM Tree
- Leaves are either empty or contain PCDATA
- Unlike ssd tree model, nodes are labeled with tags.