Document Object Model (DOM)

- How to provide uniform access to structured documents in diverse applications (parsers, browsers, editors, databases)?
- Overview of W3C DOM Specification
  - second one in the “XML-family” of recommendations
    - » Level 1, W3C Rec, Oct. 1998
    - » Level 2, W3C Rec, Nov. 2000
    - » Level 3, W3C Working Draft (January 2002)
- What does DOM specify, and how to use it?

DOM: What is it?

- An object-based, language-neutral API for XML and HTML documents
  - allows programs and scripts to build documents, navigate their structure, add, modify or delete elements and content
  - Provides a foundation for developing
    querying, filtering,
    transformation, rendering etc.
    applications on top of DOM implementations
- In contrast to "Serial Access XML" could think as "Directly Obtainable in Memory"

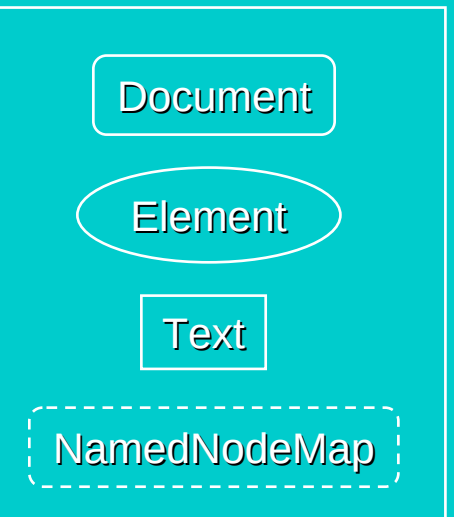
DOM *structure model*

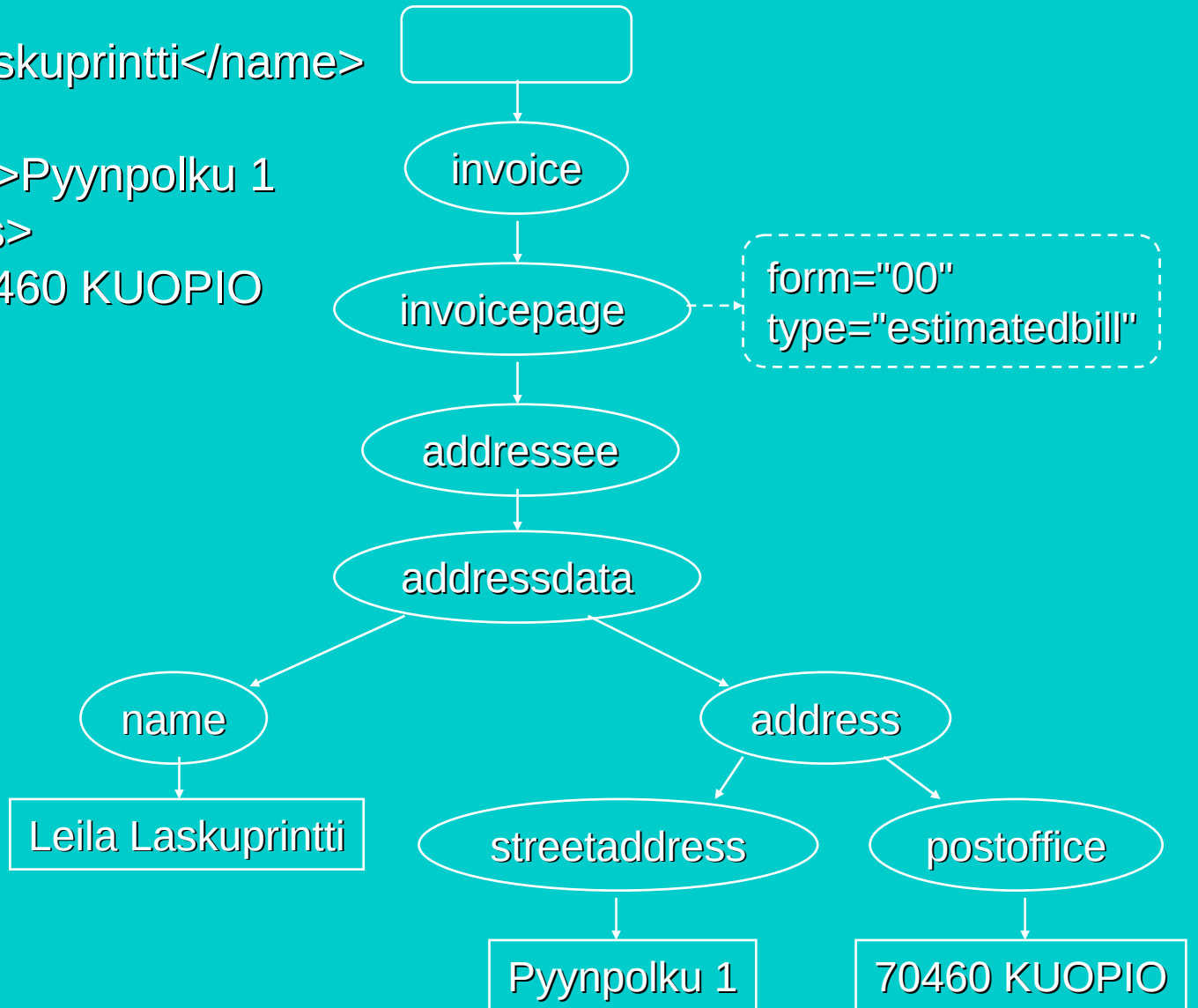
- Based on O-O concepts:
  - *methods* (to access or change object's state)
  - *interfaces* (declaration of a set of methods)
  - *objects* (encapsulation of data and methods)
- Roughly similar to the XSLT/XPath data model (to be discussed later)

  ≈ a parse tree
  - Tree-like structure implied by the abstract relationships defined by the programming interfaces;
    Does not necessarily reflect data structures used by an implementation (but probably does)

```
<invoice>
 <invoicepage form="00"
                    type="estimatedbill">
  <addressee>
   <addressdata>
    <name>Leila Laskuprintti</name>
    <address>
     <streetaddress>Pyynpolku 1
     </streetaddress>
     <postoffice>70460 KUOPIO
     </postoffice>
    </address>
   </addressdata>
  </addressee> ...
```

DOM structure model





Structure of DOM Level 1

I: DOM **Core Interfaces**

- **Fundamental interfaces**
  - » basic interfaces to structured documents
- Extended interfaces
  - » XML specific: CDATASection, DocumentType, Notation, Entity, EntityReference, ProcessingInstruction

II: DOM **HTML Interfaces**

- more convenient to access HTML documents
- (we ignore these)

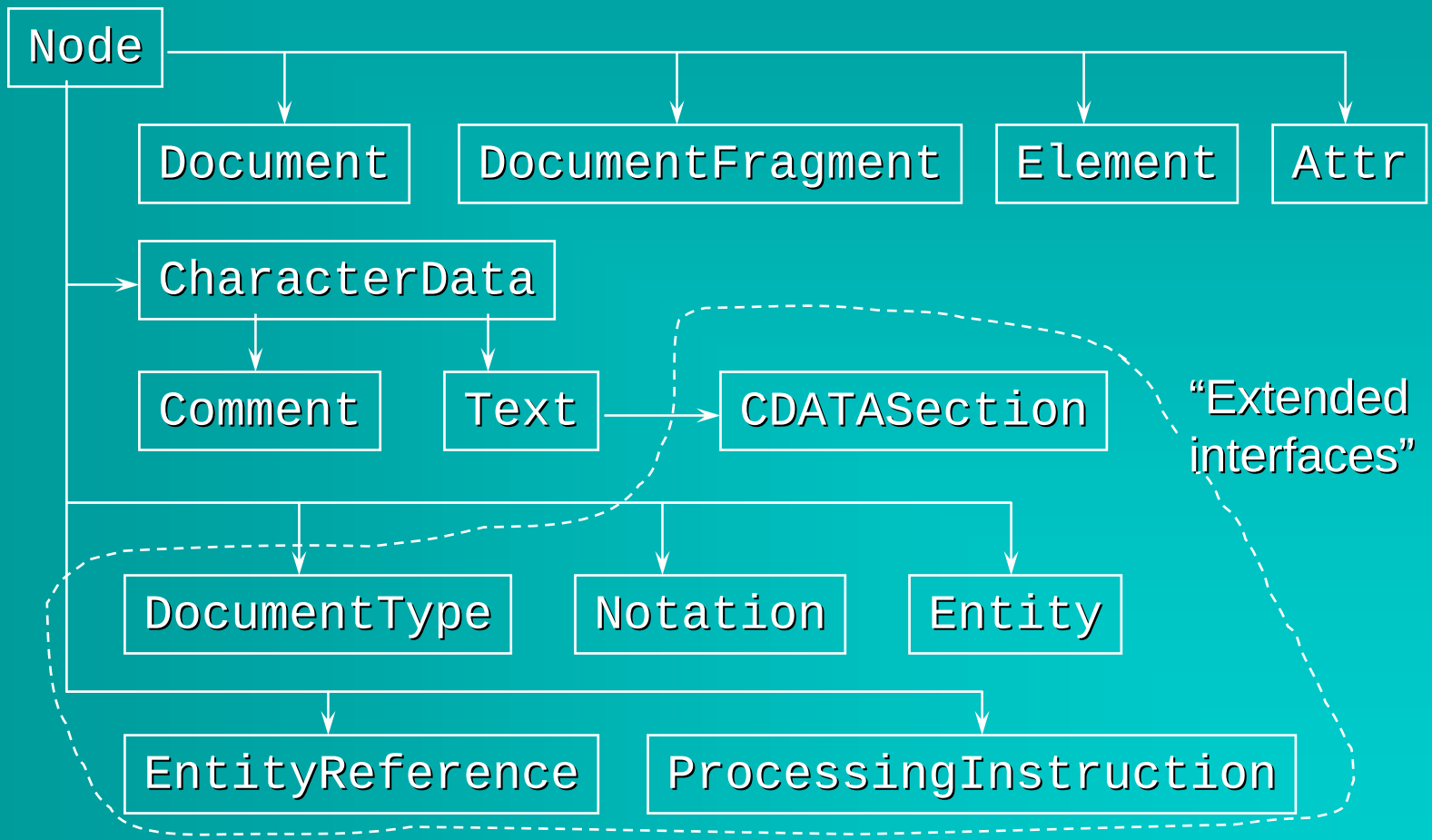
DOM Level 2

- Level 1: basic representation and manipulation of document structure and content
  (No access to the contents of a DTD)
- DOM Level 2 adds
  - support for namespaces
  - accessing elements by ID attribute values
  - optional features
    - » interfaces to document views and style sheets
    - » an event model (for, say, user actions on elements)
    - » methods for traversing the document tree and manipulating regions of document (e.g., selected by the user of an editor)
  - Loading and writing of docs **not** specified (-> Level 3)

DOM Language Bindings

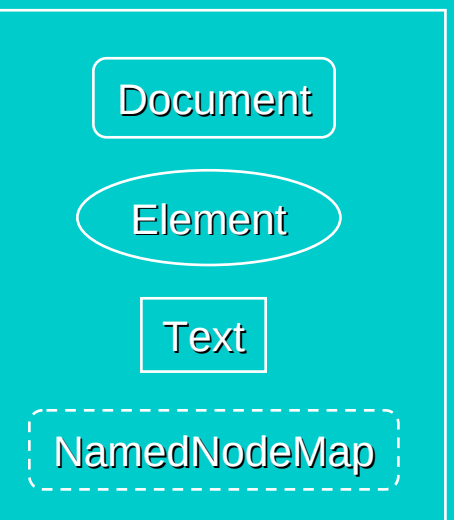
- Language-independence:
  - DOM interfaces are defined using OMG Interface Definition Language (IDL; Defined in Corba Specification)
- Language bindings (implementations of DOM interfaces) defined in the Recommendation for
  - Java and
  - ECMAScript (standardised JavaScript)

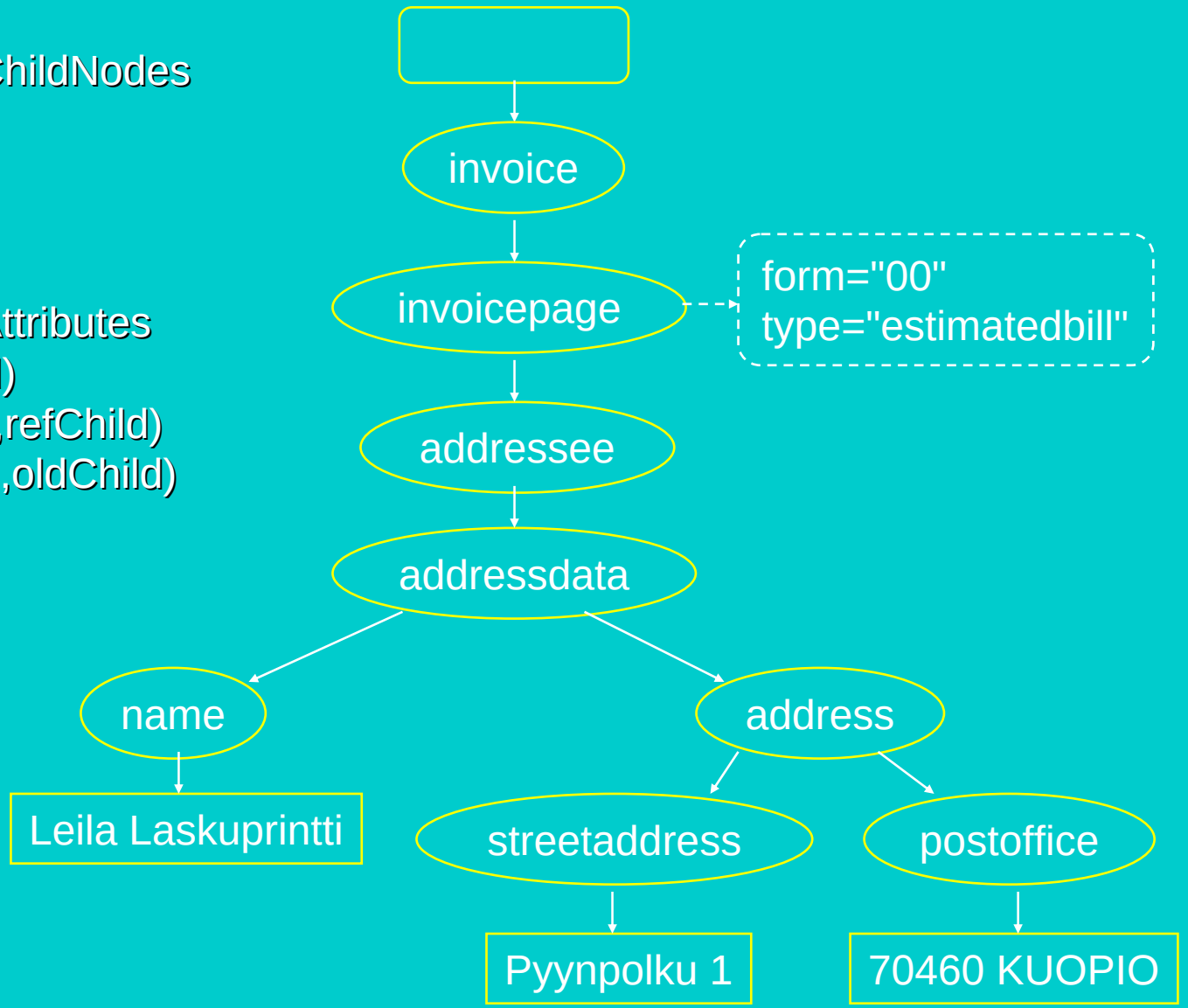
Core Interfaces: Node & its variants



DOM interfaces: Node

Node
getNodeType
getNodeValue
getOwnerDocument
getParentNode
hasChildNodes getChildNodes
getFirstChild
getLastChild
getPreviousSibling
getNextSibling
hasAttributes getAttributes
appendChild(newChild)
insertBefore(newChild,refChild)
replaceChild(newChild,oldChild)
removeChild(oldChild)





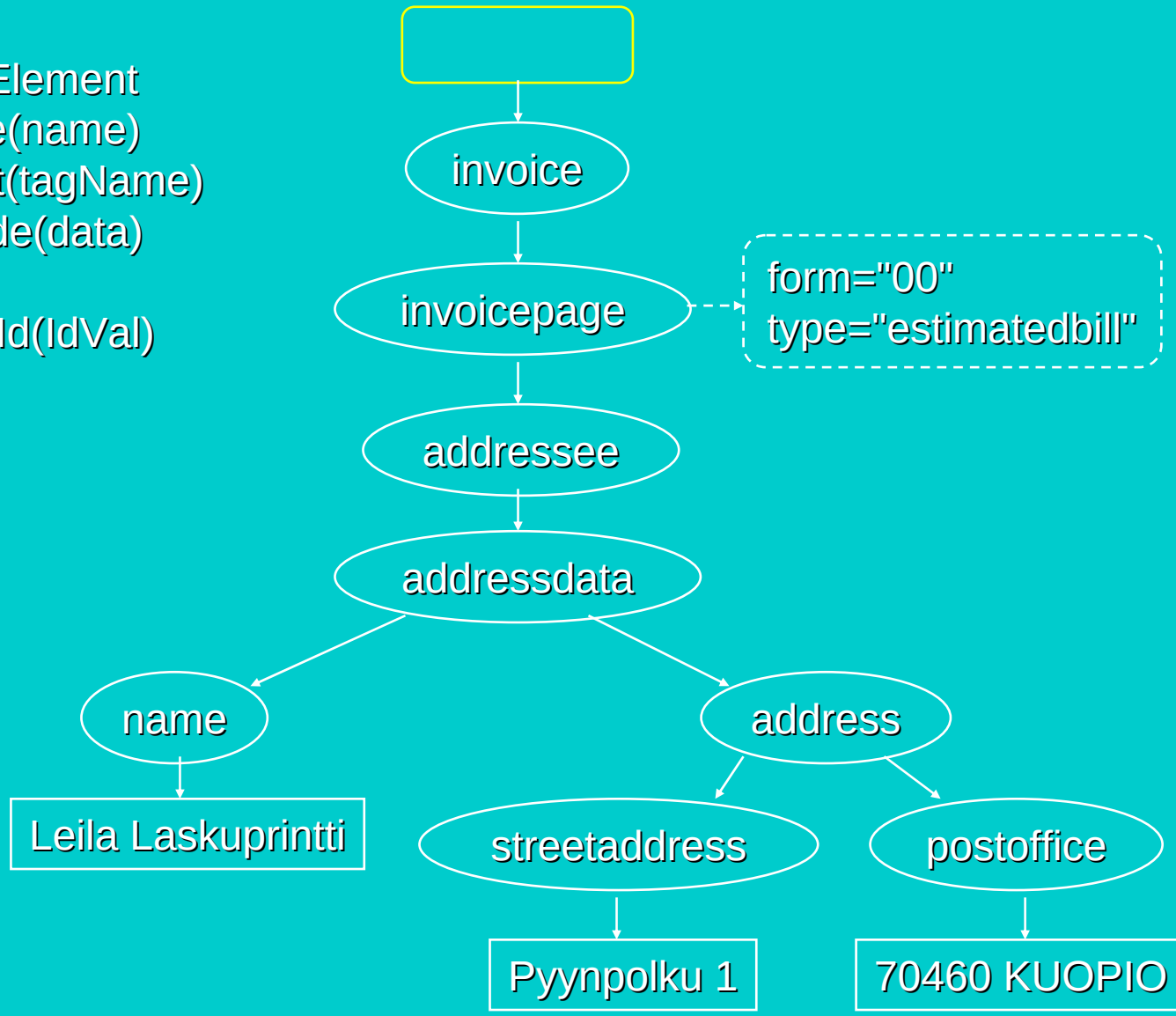
Object Creation in DOM

- Each DOM object *X* lives in the context of a `Document`: *X*`.getOwnerDocument()`
- Objects implementing interface *X* are created by factory methods
  D`.create`*X*`(…)`,
  where D is a `Document` object. E.g:
  - `createElement("A"),`
    `createAttribute("href"),`
    `createTextNode("Hello!")`
- Creation and persistent saving of `Documents` left to be specified by implementations

DOM interfaces: Document

Node

Document
getDocumentElement
createAttribute(name)
createElement(tagName)
createTextNode(data)
getDocType()
getElementById(IdVal)



Document

Element

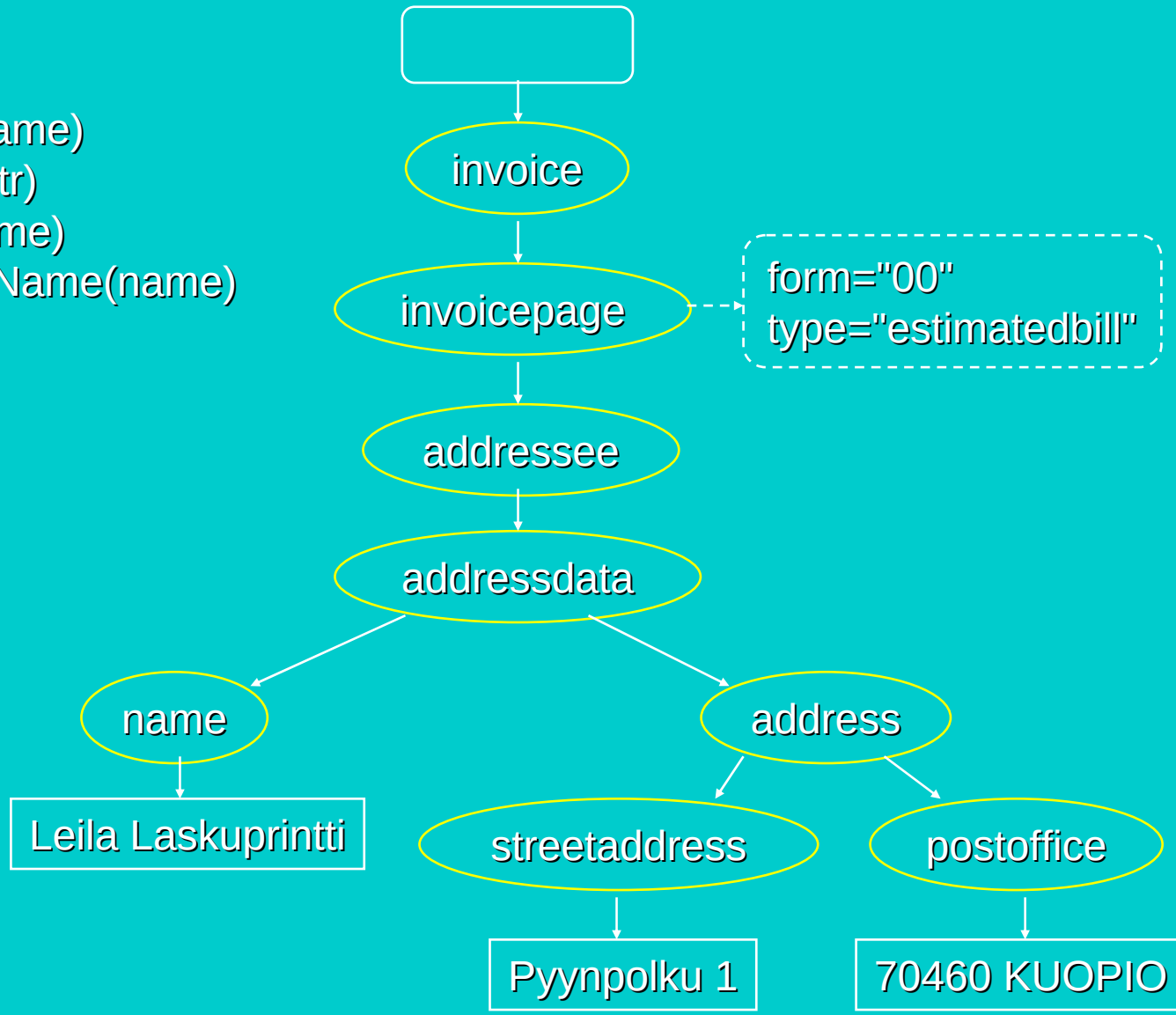
Text

NamedNodeMap

DOM interfaces: Element

Node

Element
getTagName
getAttributeNode(name)
setAttributeNode(attr)
removeAttribute(name)
getElementsByTagName(name)
hasAttribute(name)



Document

Element

Text

NamedNodeMap

Accessing properties of a Node

- **`Node.getNodeName`**()
  - for an `Element = getTagName()`
  - for an `Attr:` the name of the attribute
  - for `Text = "#text"` etc
- **`Node.getNodeValue()`**
  - content of a text node, value of attribute, …; **null** for an `Element` (!!)
    (in XSLT/Xpath: the full textual content)
- **`Node.getNodeType()`**: numeric constants (1, 2, 3, …, 12) for `ELEMENT_NODE, ATTRIBUTE_NODE, TEXT_NODE, …, NOTATION_NODE`

Content and element manipulation

- Manipulating **`CharacterData`** D:
  - D**`.substringData(`**offset, count**`)`**
  - D**`.appendData(`**string**`)`**
  - D**`.insertData(`**offset, string**`)`**
  - D**`.deleteData(`**offset, count**`)`**
  - D**`.replaceData(`**offset, count, string**`)`**
    `(= delete + insert)`
- Accessing attributes of an **`Element`** object E:
  - E**`.getAttribute(`**name**`)`**
  - E**`.setAttribute(`**name, value**`)`**
  - E**`.removeAttribute(`**name**`)`**

Additional Core Interfaces (1)

- **`NodeList`** for ordered lists of nodes
  - e.g. from `Node.getChildNodes()` or `Element.getElementsByTagName("name")`
    - » all descendant elements of type `"name"` in document order (wild-card `"*"` matches any element type)
- Accessing a specific node, or iterating over all nodes of a **`NodeList`**:
  - E.g. Java code to process all children:

```
for (i=0;
 i<node.getChildNodes().getLength();
 i++)
 process(node.getChildNodes().item(i));
```

Additional Core Interfaces (2)

- **`NamedNodeMap`** for unordered sets of nodes accessed by their name:
  - e.g. from `Node.getAttributes()`
- `NodeLists` and `NamedNodeMaps` are "live":
  - changes to the document structure reflected to their contents

DOM: Implementations

- Java-based parsers
  e.g. **IBM XML4J, Apache Xerces, Apache Crimson**
- MS IE5 browser: COM programming interfaces for C/C++ and MS Visual Basic, ActiveX object programming interfaces for script languages
- XML::DOM (Perl implementation of DOM Level 1)
- Others? Non-parser-implementations? (Participation of vendors of different kinds of systems in DOM WG has been active.)

A Java-DOM Example

- A stand-alone toy application `BuildXml`
  - either creates a new `db` document with two `person` elements, or adds them to an existing `db` document
  - based on the example in Sect. 8.6 of *Deitel et al: XML - How to program*
- Technical basis
  - DOM support in Sun JAXP
  - native XML document initialisation and storage methods of the JAXP 1.1 default parser (Apache Crimson)

Code of `BuildXml` (1)

- Begin by importing necessary packages:

```
import java.io.*;
import org.w3c.dom.*;
import org.xml.sax.*;
import javax.xml.parsers.*;
// Native (parse and write) methods of the
// JAXP 1.1 default parser (Apache Crimson):
import org.apache.crimson.tree.XmlDocument;
```

Code of `BuildXml` (2)

- Class for modifying the document in file `fileName`:

```
public class BuildXml {
  private Document document;

public BuildXml(String fileName) {
  File docFile = new File(fileName);
  Element root = null; // doc root elemen
  // Obtain a SAX-based parser:
  DocumentBuilderFactory factory =
      DocumentBuilderFactory.newInstance();
```

Code of BuildXml (3)

```
try { // to get a new DocumentBuilder:
   documentBuilder builder =
      factory.newInstance();

  if (!docFile.exists()) { //create new doc
     document = builder.newDocument();
     // add a comment:
     Comment comment =
           document.createComment(
                 "A simple personnel list");
     document.appendChild(comment);
     // Create the root element:
     root = document.createElement("db");

     document.appendChild(root);
```

Code of BuildXml (4)

... or if docFile already exists:

```
  } else   { // access an existing doc
    try { // to parse docFile
      document = builder.parse(docFile);
      root = document.getDocumentElement();
    } catch (SAXException se) {
      System.err.println("Error: " +
            se.getMessage() );
      System.exit(1);
    }

    /* A similar catch for a possible IOException */
```

Code of `BuildXml` (5)

- Create and add two child elements to `root`:

```
Node personNode =
    createPersonNode(document, "1234",
                     "Pekka", "Kilpeläinen");
root.appendChild(personNode);
personNode =
    createPersonNode(document, "5678",
                         "Irma", "Könönen");
root.appendChild(personNode);
```

Code of `BuildXml` (6)

- Finally, store the result document:

```
try { // to write the
      // XML document to file fileName
  ((XmlDocument) document).write(
     new FileOutputStream(fileName));
} catch ( IOException ioe ) {
      ioe.printStackTrace();
}
```

Subroutine to create person elements

```
public Node createPersonNode(Document document,
      String idNum, String fName, String lName) {
  Element person =
            document.createElement("person");
  person.setAttribute("idnum", idNum);
  Element firstName =
            document. createElement("first");
   person.appendChild(firstName);
  firstName. appendChild(
            document. createTextNode(fName) );
  /* ... similarly for a lastName */
  return person;
}
```

The main routine for `BuildXml`

```
public static void main(String args[]){
  if (args.length > 0) {
     String fileName = args[0];
     BuildXml buildXml = new
                  BuildXml(fileName);
  } else {
     System.err.println(
           "Give filename as argument");
  };
} // main
```

Summary of XML APIs

- XML processors make the structure and contents of XML documents available to applications through APIs
- Event-based APIs
  - notify application through parsing events
  - e.g., the SAX call-back interfaces
- Object-model (or tree) based APIs
  - provide a full parse tree
  - e.g, DOM, W3C Recommendation
  - more convenient, but may require too much resources with the largest documents
- Major parsers support both SAX and DOM