Lesson 15 - XML

STAT 133

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Adapted from Gaston Sanchez's Fall 2015 STAT133 lectures.
`github.com/gastonstat`
Course web: `github.com/STAT133-Summer2016/CourseMaterials`

XML

XML & HTML

This lecture will be a **crash introduction to XML and HTML**. You'll get a gist of how the two languages work so that you can do basic manipulations of data written in these languages, but **this will be far from comprehensive**.

Datasets

So far we've been working with tabular data

tabular

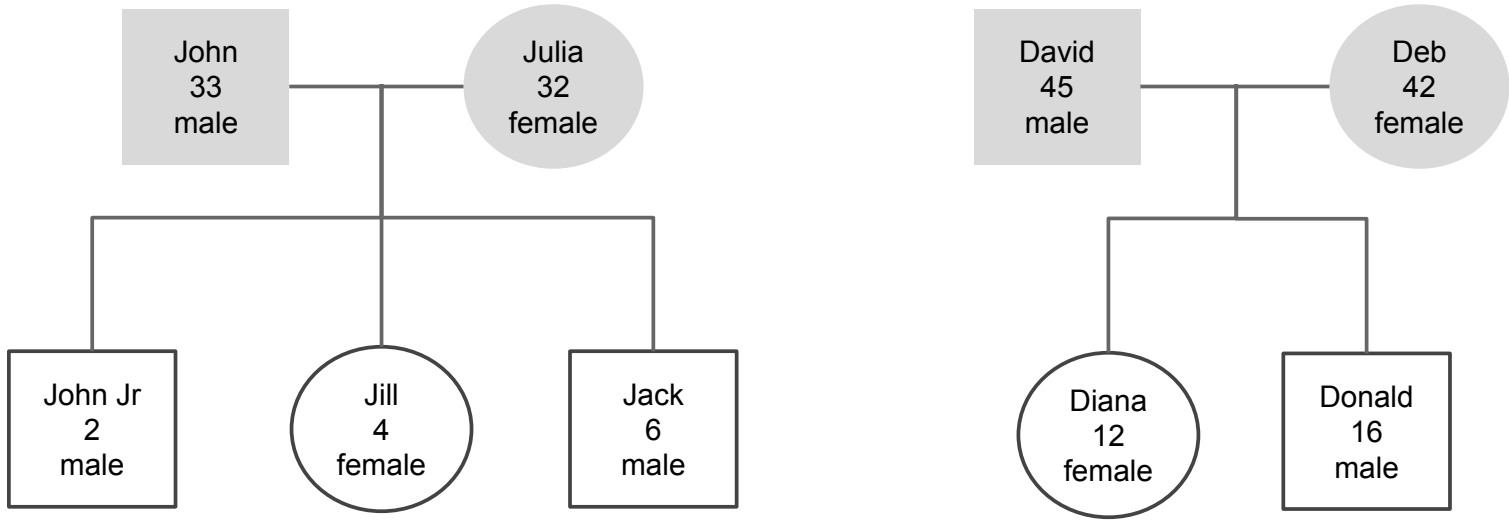
non-tabular

Motivation

Two main limitations of field-delimited files

- In plain text formats there is no information to describe the location of the data values
- There is no recognizable label for each data value within the file
- Serious limitations to store data with hierarchical structure

Hierarchical data



Hierarchical data

Field-delimited files have limitations with hierarchical data

```
                    John        33  male
                    Julia       32  female
John    Julia       Jack         6  male
John    Julia       Jill         4  female
John    Julia       John jnr     2  male
                    David       45  male
                    Debbie      42  female
David   Debbie      Donald      16  male
David   Debbie      Dianne      12  female
```

XML format

XML advantages

- XML is a storage format that is still based on plain text
- In XML formats every single value is distinctly labeled
- Moreover, every single value is self-described
- The information is organized in a much more sophisticated manner

Hierarchical data

An example of hierarchical data in XML

```
<family>
  <parent gender="male" name="John" age="33" />
  <parent gender="female" name="Julia" age="32" />
  <child gender="male" name="Jack" age="6" />
  <child gender="female" name="Jill" age="4" />
  <child gender="male" name="John jnr" age="2" />
</family>
<family>
  <parent gender="male" name="David" age="45" />
  <parent gender="female" name="Debbie" age="42" />
  <child gender="male" name="Donald" age="16" />
  <child gender="female" name="Dianne" age="12" />
</family>
```

XML and HTML

Why should you care about XML and HTML?

- Large amounts of data and information are stored, shared and distributed using HTML and XML-dialects
- They are widely adopted and used in many applications
- Working with data from the Web means dealing with HTML

XML

eXtensible Markup Language

Some Definitions

"XML is a markup language that defines a set of rules for encoding documents in a format that is both human-readable and machine-readable"

`http://en.wikipedia.org/wiki/XML`

"XML is a data description language used for describing data"

Paul Murrell

Introduction to Data Technologies

Some Definitions

"XML is a very general structure with which we can define any number of new formats to represent arbitrary data"

"XML is a standard for the semantic, hierarchical representation of data"

Deb Nolan & Duncan Temple Lang

XML and Web Technologies for Data Sciences with R

About XML

XML

XML stands for **eXtensible Markup Language**

Broadly speaking ...

XML provides a flexible framework to create formats for describing and representing data

Markups

Markup

A **markup** is a sequence of characters or other symbols inserted at certain places in a document to indicate either:

- how the content should be displayed when printed or in screen
- describe the document's structure

Markups

Markup Language

A markup language is a system for **annotating** (i.e. *marking*) a document in a way that the content is distinguished from its representation (eg LaTeX, PostScript, HTML, SVG)

LaTeX example

```
\documentclass{article}
\usepackage{graphicx}

\begin{document}

\title{Introduction to XML}
\author{First Last}
\maketitle

\section{Introduction}
Here is the text of your introduction.

\begin{equation}
    \label{simple_equation}
    \alpha = \sqrt{ \beta }
\end{equation}

\subsection{Subsection Heading Here}
Write your subsection text here.

\begin{figure}
    \centering
    \includegraphics[width=3.0in]{myfigure}
    \caption{Simulation Results}
    \label{simulationfigure}
\end{figure}

\end{document}
```

Markups

XML Markups

In XML (as well as in HTML) the marks (aka *tags*) are defined using angle brackets: <>

```
<mark>Text marked with special tag</mark>
```

Extensible

Extensible?

The concept of *extensibility* means that we can define our own marks, the order in which they occur, and how they should be processed. For example:

- `<my_mark>`
- `<awesome>`
- `<boring>`
- `<cool>`

About XML

XML is NOT

- a programming language
- a network transfer protocol
- a database

About XML

XML is

- more than a markup language
- a generic language that provides structure and syntax for representing any type of information
- a meta-language: it allows us to create or define other languages

XML Applications

Some XML dialects

- **KML** (*Keyhole Markup Language*) for describing geo-spatial information used in Google Earth, Google Maps, Google Sky
- **SVG** (*Scalable Vector Graphics*) for visual graphical displays of two-dimensional graphics with support for interactivity and animation
- **PMML** (*Predictive Model Markup Language*) for describing and exchanging models produced by data mining and machine learning algorithms

Keyhole Markup Language example

```
<?xml version="1.0" encoding="UTF-8"?>
<kml xmlns="http://www.opengis.net/kml/2.2">
<Document>
<Placemark>
  <name>New York City</name>
  <description>New York City</description>
  <Point>
    <coordinates>-74.006393,40.714172,0</coordinates>
  </Point>
</Placemark>
</Document>
</kml>
```

Scalable Vector Graphics example

```
<svg width="100" height="100">
  <circle cx="50" cy="50" r="40" stroke="green" stroke-width="4" />
</svg>


<svg width="400" height="110">
  <rect width="300" height="100" style="fill:rgb(0,0,255)" />
</svg>
```

Minimalist Example

XML Example

Ultra Simple XML

```
<movie>
  Good Will Hunting
</movie>
```

XML Example

Ultra Simple XML

```
<movie>
  Good Will Hunting
</movie>
```

- one single element *movie*
- start-tag: `<movie>`
- end-tag: `</movie>`
- content: `Good Will Hunting`

XML Example

Ultra Simple XML

```
<movie mins="126" lang="en">
  Good Will Hunting
</movie>
```

- xml elements can have **attributes**
- attributes: `mins` (minutes) and `lang` (language)
- attributes are *attached* to the element's start tag
- attribute values **must be quoted!**

XML Example

Minimalist XML

```
<movie mins="126" lang="en">
  <title>Good Will Hunting</title>
  <director>Gus Van Sant</director>
  <year>1998</year>
  <genre>drama</genre>
</movie>
```

- an xml element may contain other elements
- *movie* contains several elements: *title*, *director*, *year*, *genre*

XML Example

Simple XML

```
<movie mins="126" lang="en">
  <title>Good Will Hunting</title>
  <director>
    <first_name>Gus</first_name>
    <last_name>Van Sant</last_name>
  </director>
  <year>1998</year>
  <genre>drama</genre>
</movie>
```

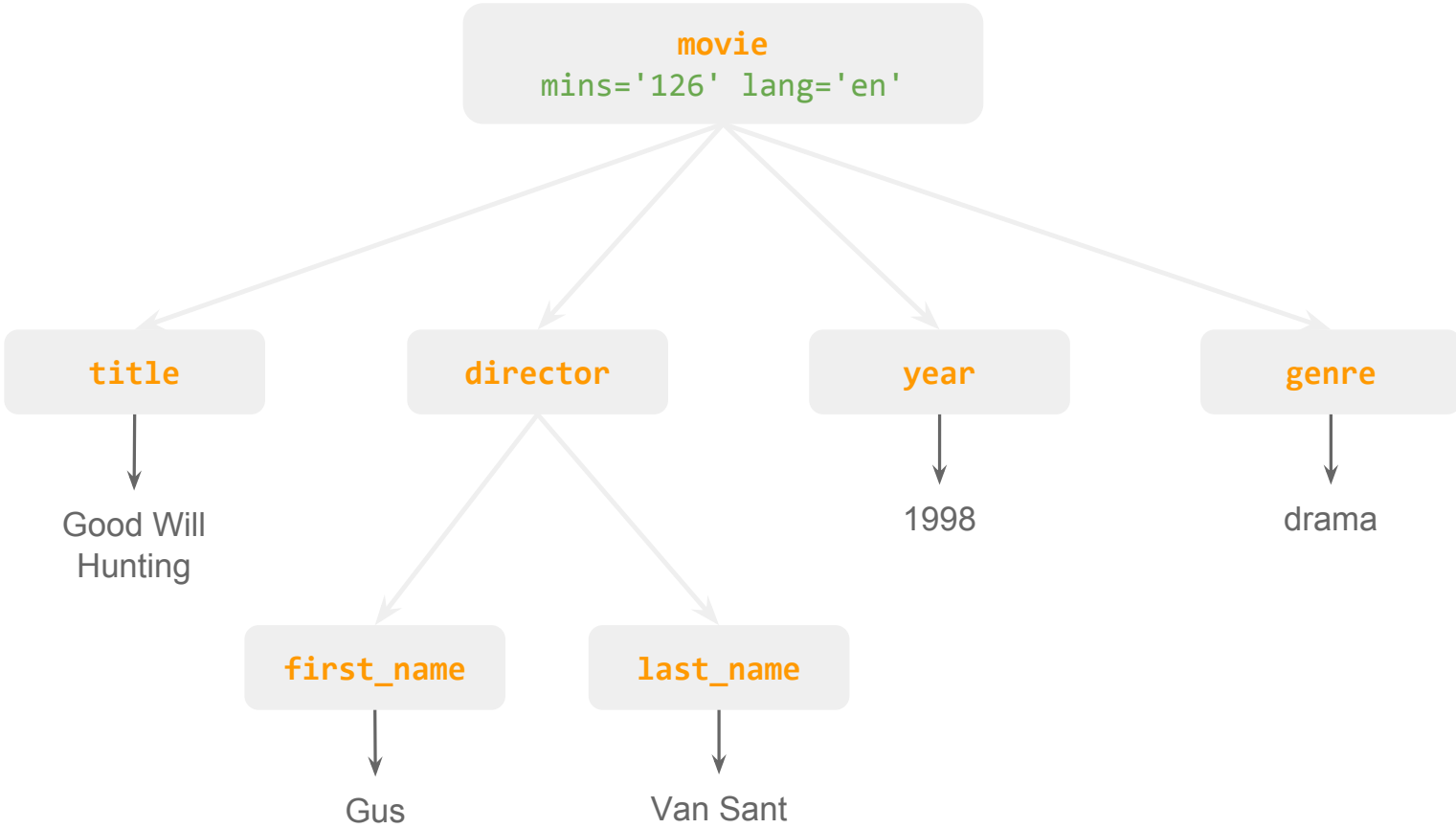
- Now *director* has two child elements: *first_name* and *last_name*

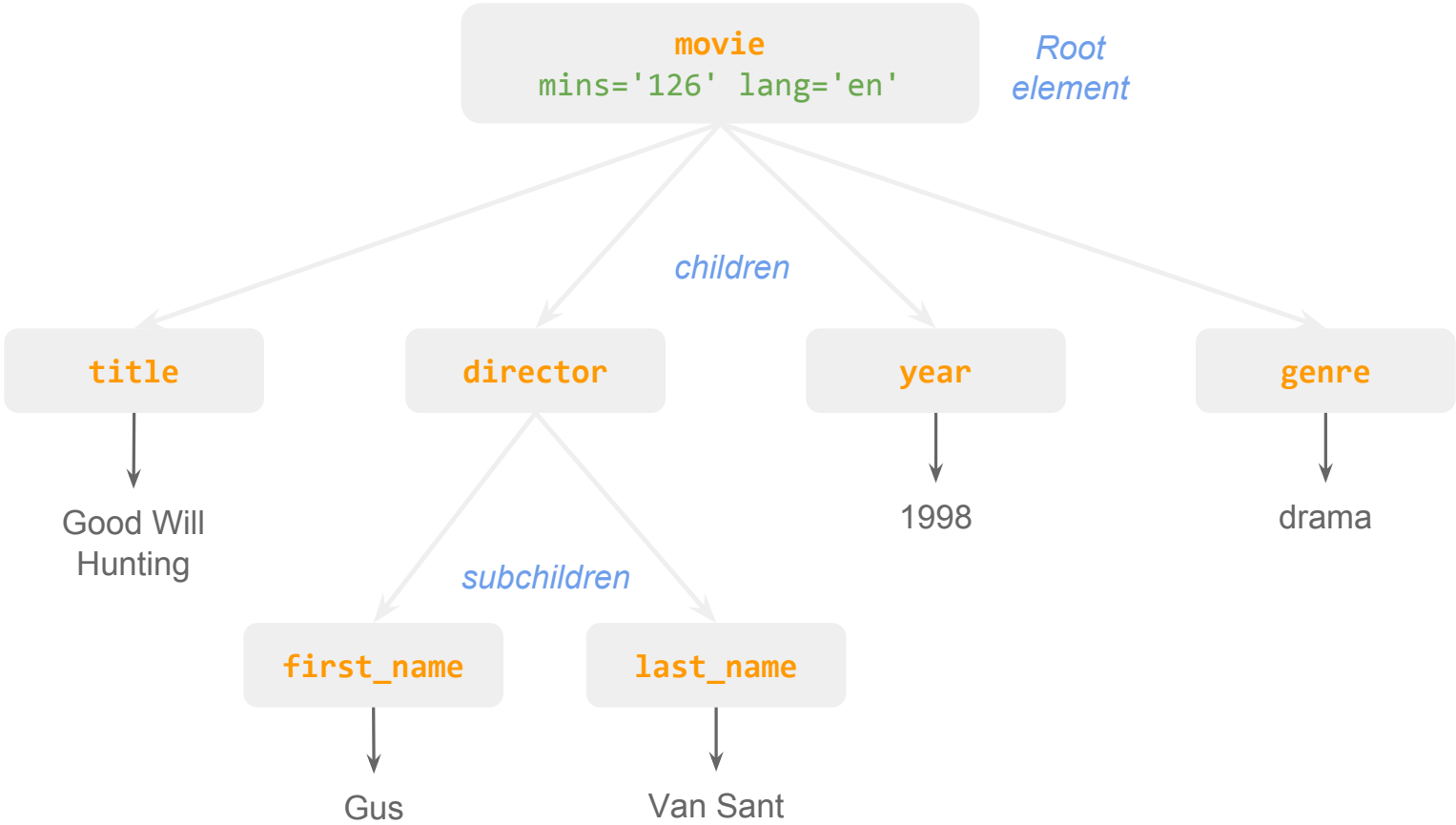
XML Hierarchy Structure

Conceptual XML

```
<Root>
  <child_1>...</child_1>
  <child_2>...</child_2>
    <subchild>...</subchild>
  <child_3>...</child_3>
</Root>
```

- An XML document can be represented with a **tree structure**
- An XML document must have **one single Root** element
- The `Root` may contain `child` elements
- A `child` element may contain `subchild` elements


movie
mins='126' lang='en'
title
director
year
genre
Good Will Hunting
1998
drama
first_name
last_name
Gus
Van Sant


movie
mins='126' lang='en'
Root element
children
title
director
year
genre
Good Will Hunting
1998
drama
subchildren
first_name
last_name
Gus
Van Sant

Well-Formedness

Well-formed XML

We say that an XML document is **well-formed** when it obeys the basic syntax rules of XML. Some of those rules are:

- one root element containing the rest of elements
- properly nested elements
- self-closing tags
- attributes appear in start-tags of elements
- attribute values must be quoted
- element names and attribute names are case sensitive

Well-Formedness

```
<movie mins="126" lang="en">
  <title>Good Will Hunting</title>
  <director>
    <first_name>Gus</first_name>
    <last_name>Van Sant</last_name>
  </director>
  <year>1998</year>
  <genre>drama</genre>
</movie>
```

Well-Formedness

Importance of Well-formed XML

Not well-formed XML documents produce potentially fatal errors or warnings when parsed.

Documents may be well-formed but not valid. Well-formed just guarantees that the document meets the basic XML structure, not that the content is valid.

Additional XML Elements

Some Additional Elements

```
<?xml version="1.0"? encoding="UTF-8" ?>
<![CDATA[ a > 5 & b < 10 ]]>
<?GS print(format = TRUE)>
<!DOCTYPE Movie>
<!-- This is a comment -->
<movie mins="126" lang="en">
  <title>Good Will Hunting</title>
  <director>
    <first_name>Gus</first_name>
    <last_name>Van Sant</last_name>
  </director>
  <year>1998</year>
  <genre>drama</genre>
</movie>
```

Additional Optional XML Elements

Markup	Description
`<?xml ?>`	XML Declaration
	identifies content as an XML document
`<?PI ?>`	Processing Instruction
	processing instructions passed to application `PI`
`<!DOCTYPE >`	Document-type Declaration
	defines the structure of an XML document
`<![CDATA[ ]]>`	CDATA Character Data
	anything inside a CDATA is ignored by the parser
`<!-- -->`	Comment
	for writing comments

DTD

Document-Type Declaration

The Document-type Declaration identifies the **type** of the document. The *type* indicates the structure of a **valid** document:

- what elements are allowed to be present
- how elements can be combined
- how elements must be ordered

Basically, the DTD specifies what the format allows you to do.

Wrapping Up

About XML

- designed to store and transfer data
- designed to be self-descriptive
- tags are not predefined and can be extended

Characteristics of XML

XML is

- a generic language that provides structure and syntax for many markup dialects
- is a syntax or format for defining markup languages
- a standard for the semantic, hierarchical representation of data
- provides a general approach for representing all types of information dialects

XML document example

Simple XML

```
<?xml version="1.0"?>
<!DOCTYPE movies>
<movie mins="126" lang="en">
  <!-- this is a comment -->
  <title>Good Will Hunting</title>
  <director>
    <first_name>Gus</first_name>
    <last_name>Van Sant</last_name>
  </director>
  <year>1998</year>
  <genre>drama</genre>
</movie>
```

XML Tree Structure

Each element can have:

- a Name
- any number of attributes
- optional content
- other nested elements

Traversing the tree

There's a **unique** path from the root node to any given node

XPath Language

XPath

Querying Trees

The real parsing power comes from the ability to **locate nodes and extract information from them**. For this, we need to be able to perform queries on the parsed content.

XPath

The solution is provided by **XPath**, which is a language to navigate through elements and attributes in an XML/HTML document

XPath

XPath

- is a language for finding information in an XML document
- uses path expressions to select nodes or node-sets in an XML document
- works by identifying patterns to match data or content
- includes over 100 built-in functions

About XPath

XPath Syntax

XPath uses **path expressions** to select nodes in an XML document. It has a computational model to identify sets of nodes (node-sets)

XPath Syntax

We can specify paths through the tree structure:

- based on node names
- based on node content
- based on a node's relationship to other nodes

About XPath

XPath Syntax

The key concept is knowing how to write XPath expressions. XPath expressions have a syntax similar to the way files are located in a hierarchy of directories/folders in a computer file system. For instance:

```
/movies/movie[1]
```

is the XPath expression to locate the first `movie` element that is the child of the `movies` element

Selecting Nodes

XPath Syntax

The main path expressions (i.e. symbols) are:

Symbol	Description
/	selects from the root node
//	selects nodes anywhere
.	selects the current node
..	Selects the parent of the current node
@	Selects attributes
[]	Square brackets to indicate attributes

XPath Predicates (square brackets `[]`) allow you to find a specific node or node$s$ that contains a specific value. You can use the usual comparison operators ¡, ¡=, etc. A major difference is that equality is $=$ and **NOT** $==$. An example usage might be:
`/store/gardening/plants/flowers[@avgheight>10]`
This would search the **store** document for flowers with an **attribute avgheight** greater than 10.

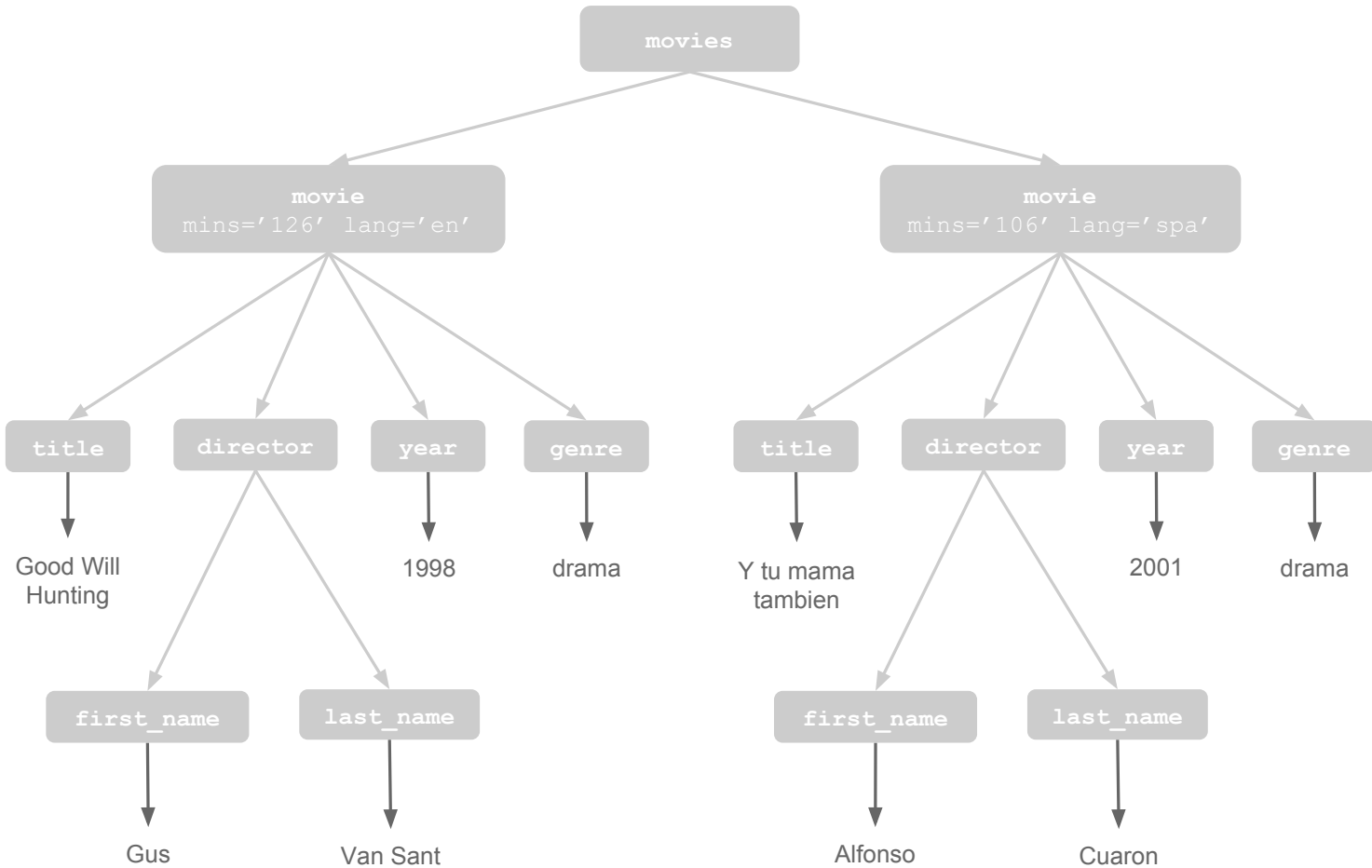
Selecting Unknown Nodes

XPath wildcards for unknown nodes

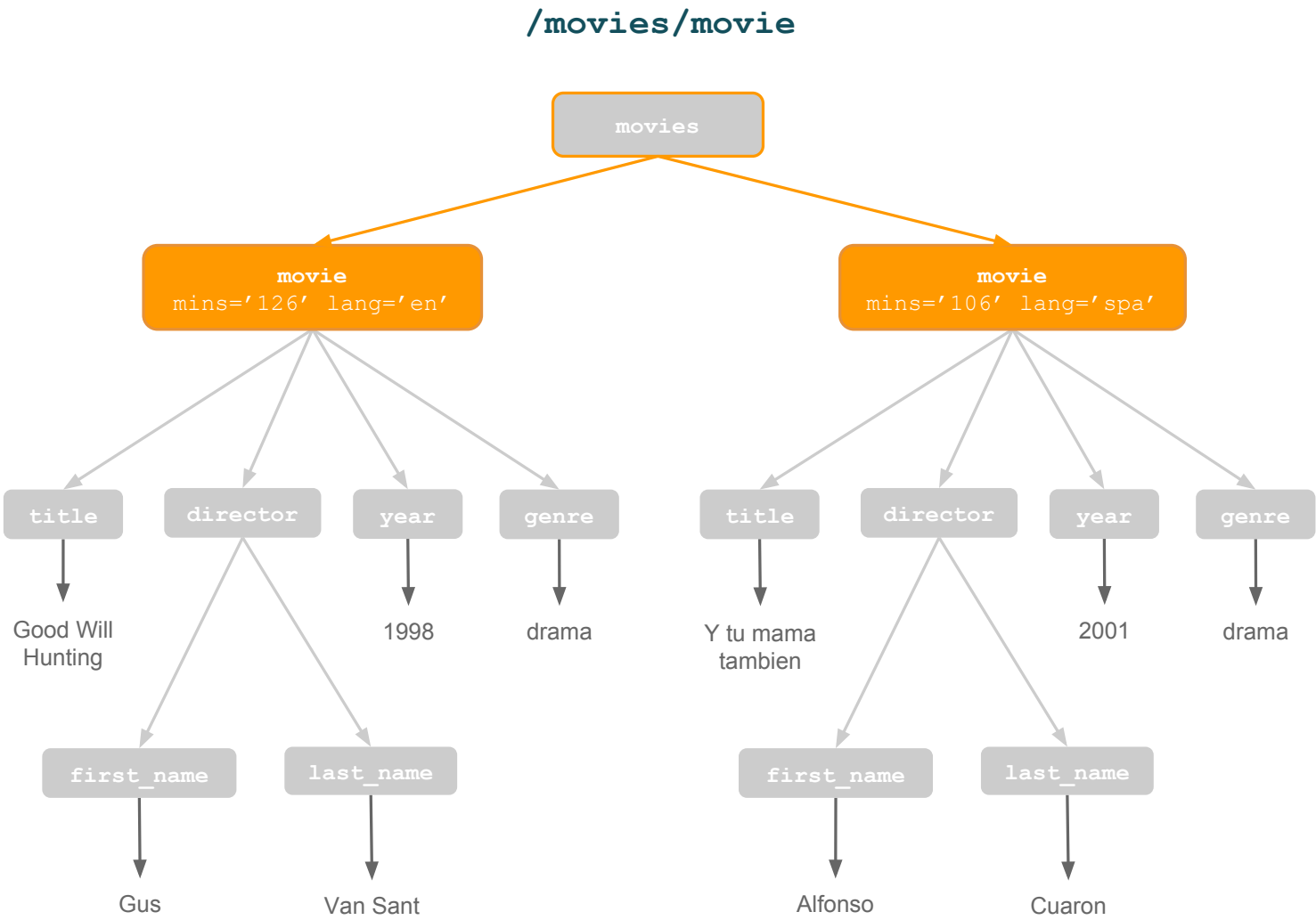
XPath wildcards can be used to select unknown XML elements

Symbol	Description
`*`	matches any element node
`@*`	matches any attribute node
`node()`	matches any node of any kind

Movies Tree Structure

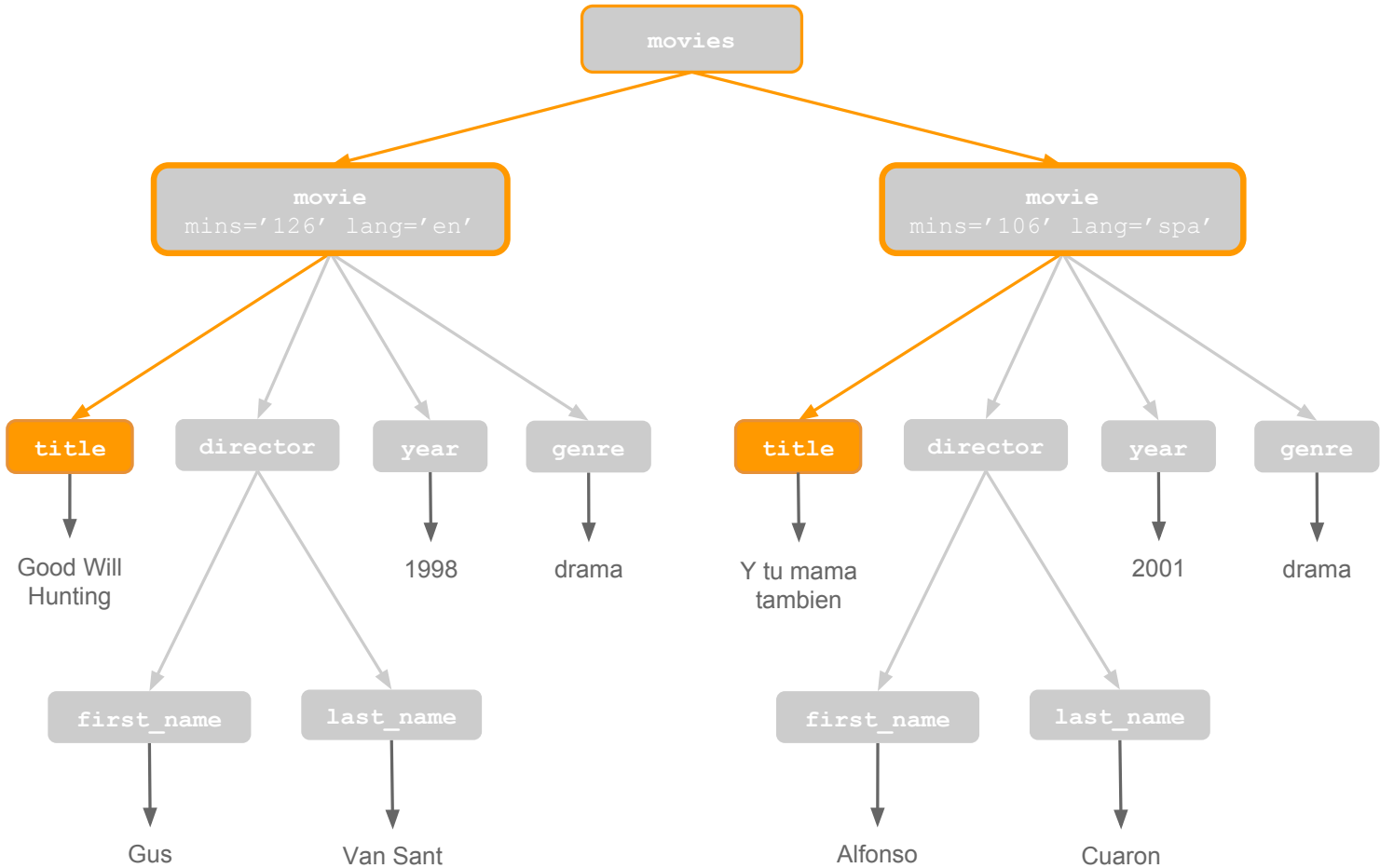


XPath: movie nodes

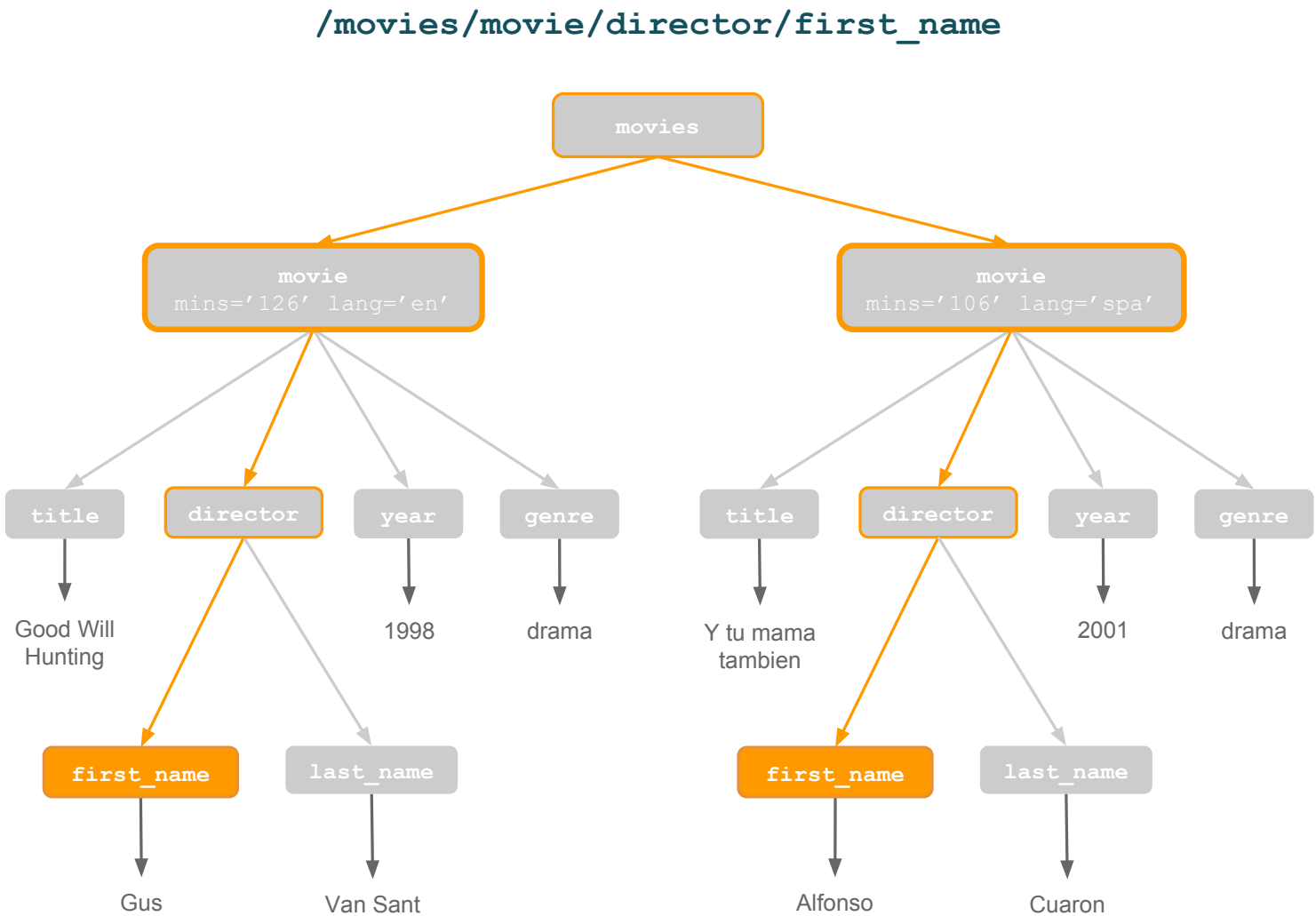


XPath: movie title nodes

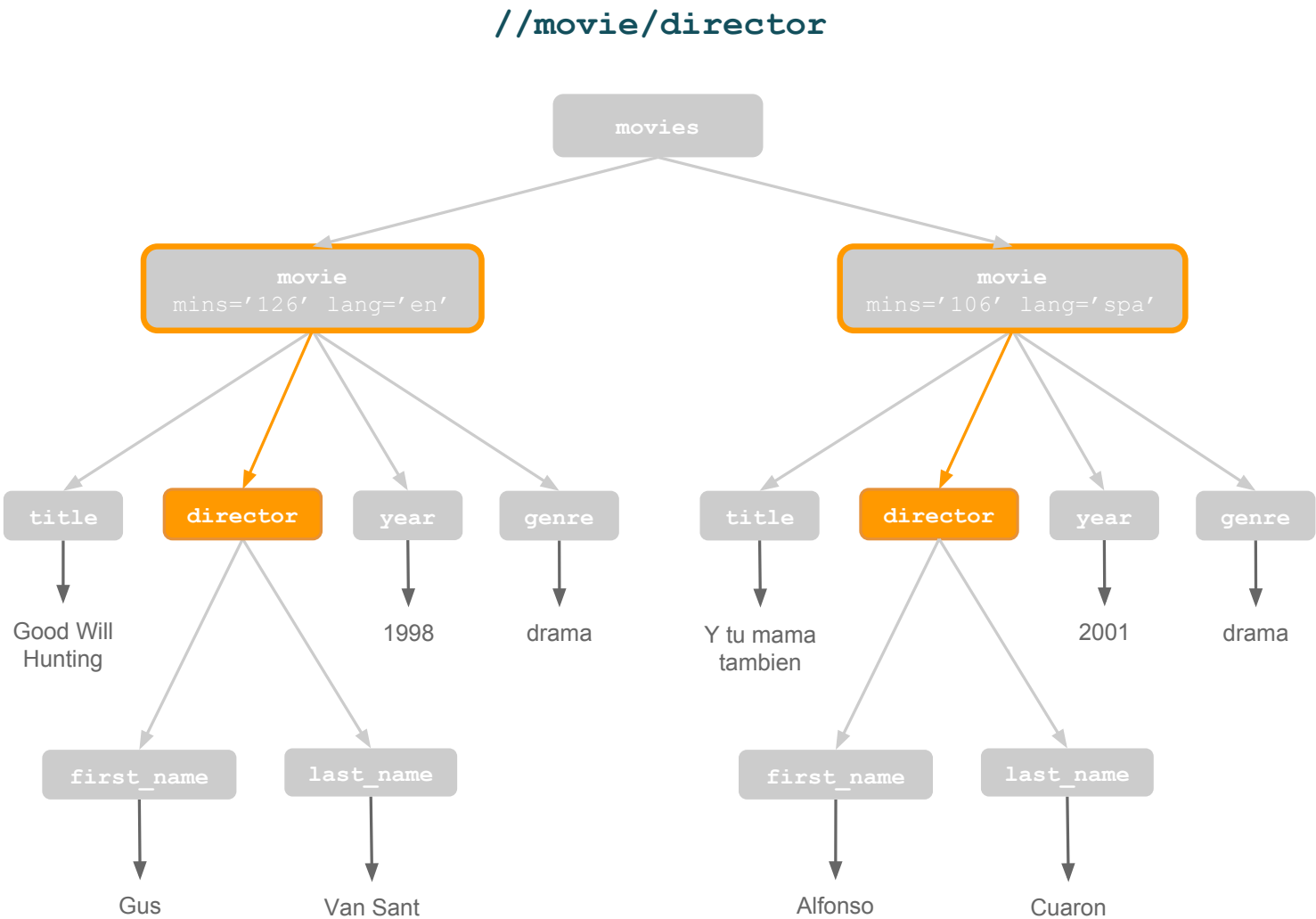
/movies/movie/title



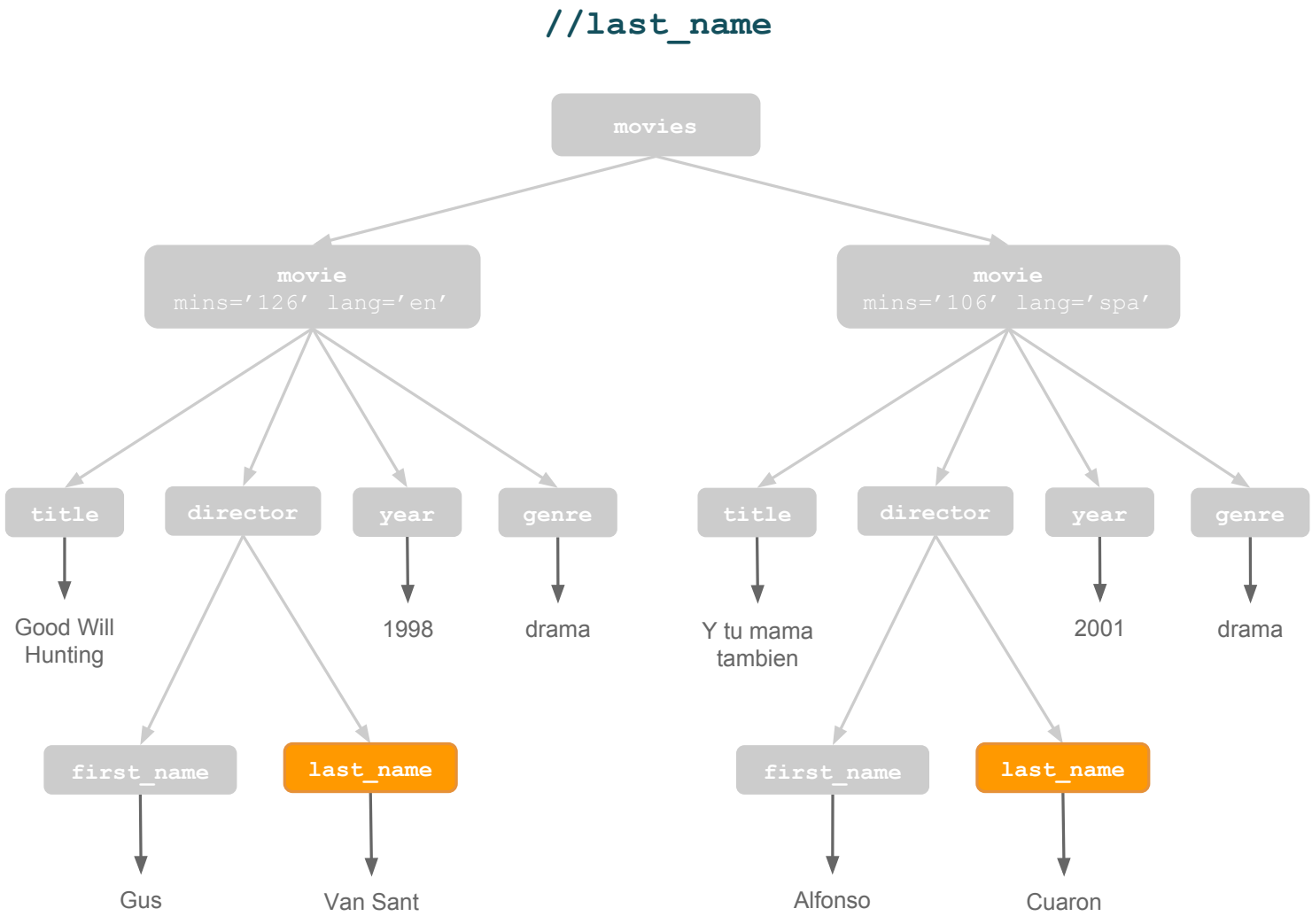
XPath: movie director's first name nodes



XPath: movie director nodes

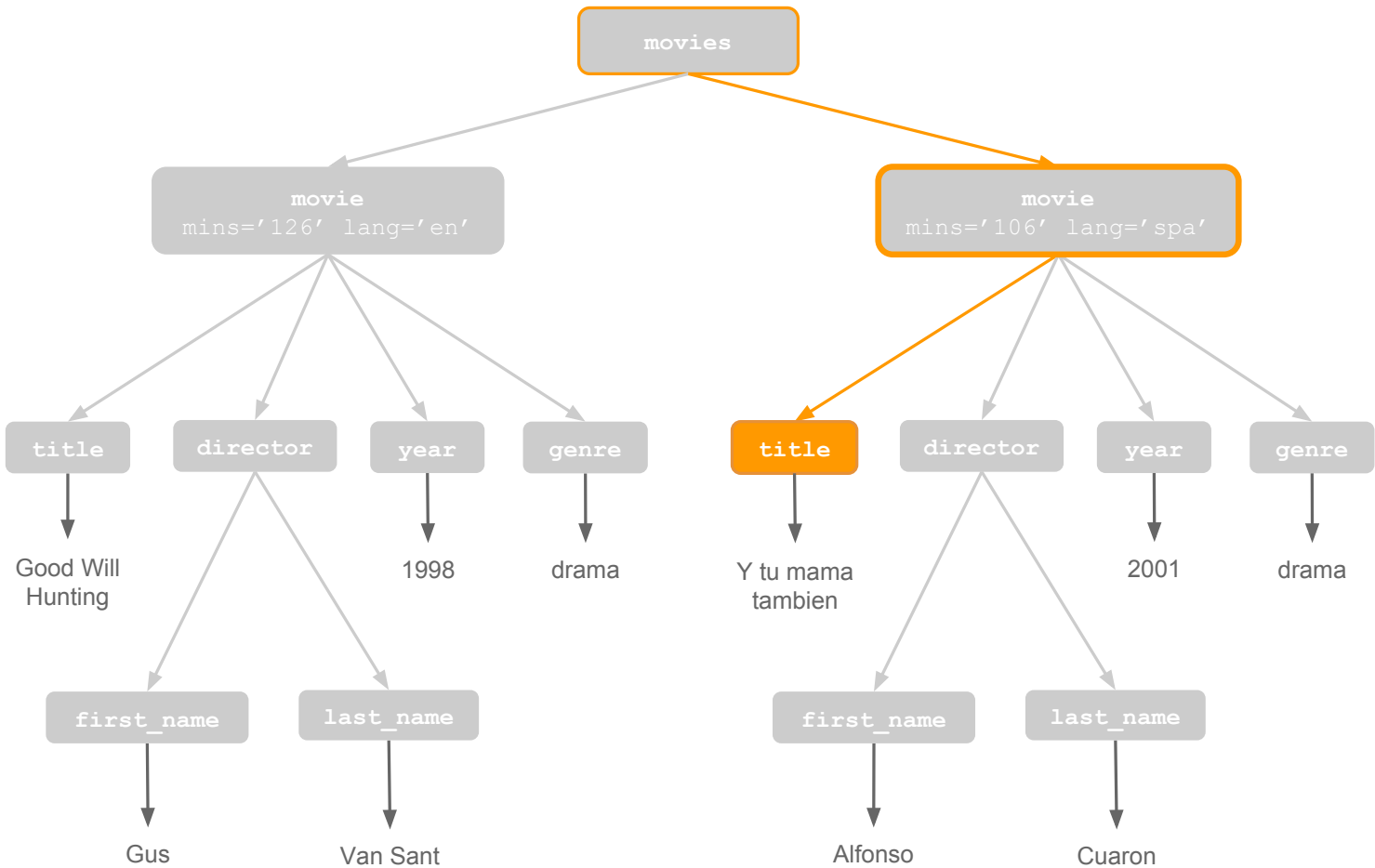


XPath: last name nodes



XPath: title node of movie in Spanish

/movies/movie[@lang='spa']/title



Querying parsed documents

XPath in "XML"

XPath in "xml2"

To work with XPath expressions using the "xml2" package, we have the auxiliary function `xml_find_all()` that accepts XPath expressions in order to select node-sets. Its main usage is:

```
xml_find_all(xml_doc, xpath)
```

where `doc` is an object of class "xml_document" and `xpath` is a string giving the XPath expression to be evaluated

Some References

- XML Files website (http://www.xmlfiles.com)
  by Jan Egil Refsnes
- XML in a Nutshell
  by Elliotte Rusty Harold; W. Scott Means
- XML Tutorial (http://www.w3schools.com/xml/default.asp)
  by w3schools
- Introduction to Data Technologies
  by Paul Murrell
- XML and Web Technologies for Data Sciences with R
  by Deb Nolan and Duncan Temple Lang
- xml2 (https://github.com/hadley/xml2)
  by Hadley Wickham