

Text Languages and Properties

Berlin Chen 2004

Reference:

1. *Modern Information Retrieval*, chapter 6

Documents

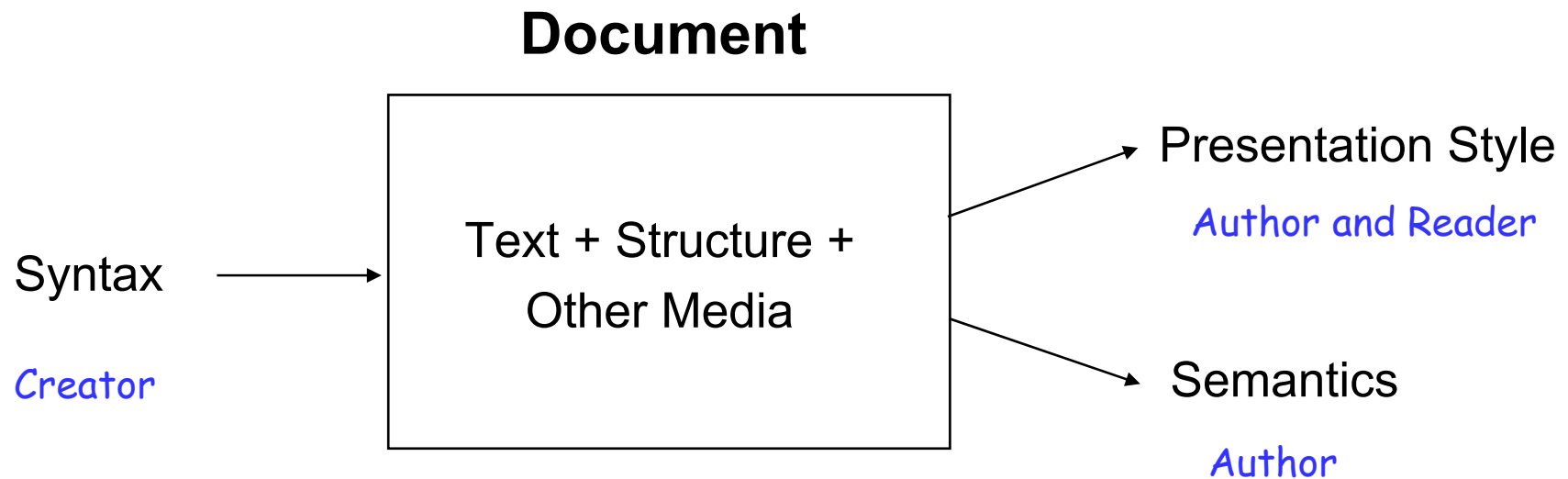
- A document is a single unit of information
 - Typical text in digital form, but can also include other media
- Two perspectives
 - Logical View
 - A unit like a research article, a book or a manual
 - Physical View
 - A unit like a file, an email, or a Web page

Syntax of a Document

- Syntax of a document can express structure, presentation style, semantics, or even external actions
 - A document can also have information about itself, called **metadata**
- The syntax of a document can be explicit in its content, or expressed in a simple declarative language or in a programming language
 - But the conversion of documents in one language to other languages (or formats) is very difficult !
 - How to flexibly interchange between applications is becoming important

Many syntax languages are proprietary and specific !

Characteristics of a Document



- The **presentation style** of a document defines how the document is visualized in a computer window or a printed page
 - But can also includes **treatment of other media such as audio or video**

Metadata

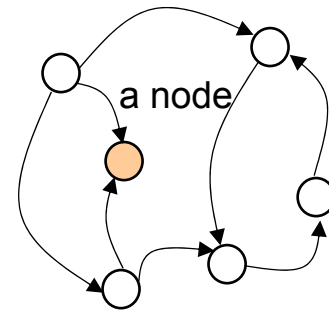
- Metadata: “data about data”
 - Is information on the organization of the data, the various data domains, and the relationship between them
- Descriptive Metadata
 - Is external to the meaning of the document and pertains more to how document was created
 - Information including author, date, source, title, length, genre, ...
 - E.g., Dublin Core Metadata Element Set
 - 15 fields to describe a doc

Metadata

- Semantic Metadata
 - Characterize the subject matter about the document's contents
 - Information including **subject codes, abstract, keywords (key terms)**
 - To standardize semantic terms, many areas use specific **ontologies**, which are **hierarchical taxonomies of terms describing certain knowledge topics**
 - E.g., Library of Congress subject codes

Web Metadata

- Used for many purposes, e.g.,
 - Cataloging
 - Content rating
 - Intellectual property rights
 - Digital signatures
 - Privacy levels
 - Electronic commerce
- RDF (Resource Description Framework)
 - A new standard for Web metadata which provides interoperability between applications
 - Allow the description of Web resources to facilitate automated processing of information



Metadata for Non-textual Objects

- Such as images, sounds, and videos
 - A set of keywords used to describe them
 - **Meta-descriptions**
 - These keywords can later be used to search for these media using classical text IR techniques
 - The emerging approach is content-based indexing
 - Content-Based Image Retrieval
 - Content-Based Speech Retrieval
 - Content-Based Music Retrieval
 - Content-Based Video Retrieval
 -

Text

- What are the possible **formats** of text ?
 - Coding schemes for languages
 - E.g., EBCDIC, ASCII, Unicode(16-bit code)
- What are the **statistical properties** of text ?
 - How the information content of text can be measured
 - The frequency of different words
 - The relation between the vocabulary size and corpus size

Factors affect IR performance and term weighting
and other aspects of IR systems

Text: Formats

- Text documents have no single format, and IR systems deal with them in two ways
 - Convert a document to an internal format
 - Disadvantage: the original application related the document is not useful any more
 - Using **filters** to handle most popular documents
 - E.g., word processors like Word, WordPerfect, ...
 - But some formats are proprietary and thus can't be filtered
 - Documents in human-readable ASCII form are more portability than those in binary form

Text: Formats

- Other text formats developed for document interchange
 - **Rich Text Format (RTF)**: used by word processors and has ASCII syntax
 - **Portable Document Format (PDF)** and **Postscript**: used for display or printing documents
 - **MIME (Multipurpose Internet Mail Exchange)**: support multiple character sets, multiple languages, and multiple media

Text: Information Theory

- Written text contains semantics for information communication
 - E.g., a text where only one symbol appears almost all the time does not convey much information
- Information theory uses **entropy** to capture information context (uncertainty) of text

Entropy: the amount of information in a text

$$E = - \sum_{i=1}^{\sigma} p_i \log_2 p_i$$

σ : number of symbols

- Given $\sigma = 2$, and the symbols coded in binary
 - Entropy is 1 if both symbols appear the same number of times
 - Entropy is 0 if only one symbol appears

Text: Information Theory

- The calculation of **entropy** depends on the probabilities of symbols which were obtained by a text model
 - The amount of information in a text is measured with regard to the text model
 - E.g., in text compression
 - Entropy is a limit on how much the text can be compressed, depending on the text model

Text: Modeling Natural Languages

- **Issue1:** Text of natural languages composed of symbols from a finite alphabet set
 - **Word-level** (within word)
 - Symbols **separating words** or **belonging to words**, and **symbols are not uniform distributed**
 - Vowel letters are more frequent than most constant letters
 - The simple binominal model (0-order Markovian model) was used to generate text
 - However, dependency for letters' occurrences was observed
 - k -order Markovian model further is used

Text: Modeling Natural Languages

- **Sentence-level** (within sentence)
 - Take words as symbols
 - k -order Markovian model was used to generate text (also called *n -gram language models*)
 - E.g., text generated by 5-order model using the distribution of words in the Bible might make sense
 - More complex models
 - Finite-state models (regular languages)
 - Grammar models (context-free and other language)

- Trigram approximation to Shakespeare
 - (a) Sweet prince, Falstaff shall die. Harry of Monmouth's grave.
 - (b) This shall forbid it should be branded, if renown made it empty.
 - (c) What is't that cried?
 - (d) Indeed the duke; and had a very good friend.
 - (e) Fly, and will rid me these news of price. Therefore the sadness of parting, as they say, 'tis done.
 - (f) The sweet! How many then shall posthumus end his miseries.

- Quadrigram approximation to Shakespeare
 - (a) King Henry. What! I will go seek the traitor Gloucester. Exeunt some of the watch. A great banquet serv'd in;
 - (b) Will you not tell me who I am?
 - (c) It cannot be but so.
 - (d) Indeed the short and the long. Marry, 'tis a noble Lepidus
 - (e) They say all lovers swear more performance than they are wont to keep obliged faith unforfeited!
 - (f) Enter Leonato's brother Antonio, and the rest, but seek the weary beds of people sick.

Text: Modeling Natural Languages

- **Issue 2: How the different words are distributed inside each documents**

- **Zipf's law** : an approximate model

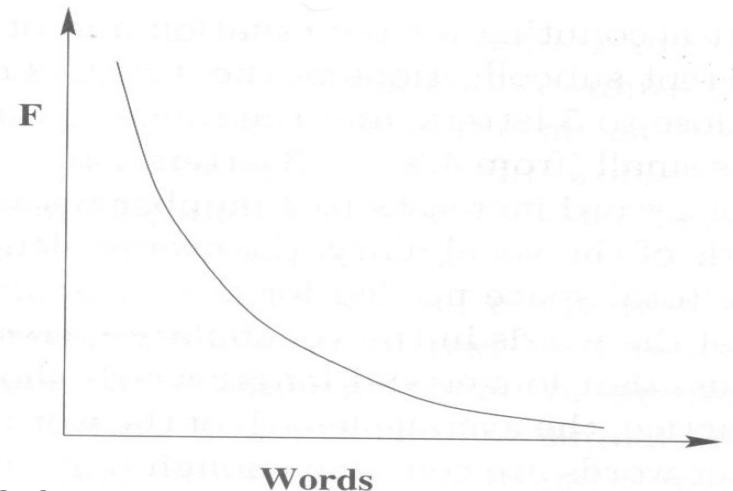
- Attempt to capture the distribution of the frequencies (number of occurrences) of the words

- The frequency of the i -th most frequent word is $1 / i^\theta$ times that of the most frequent word

- E.g., in a text of n words with a vocabulary of V words, the i -th most frequent word appears $n / (i^\theta H_V(\theta))$ times

$$H_V(\theta) = \frac{1}{1^\theta} + \frac{1}{2^\theta} + \dots + \frac{1}{V^\theta} = \sum_{j=1}^V \frac{1}{j^\theta}$$

θ : depends on the text, between 1.5 and 2.0



Text: Modeling Natural Languages

- A few hundred words take up 50% of the text !
 - Words that are too frequent (known as stopwords) can be discarded
 - Stopwords often does not carry meaning in natural language and can be ignored
 - E.g., “a,” “the,” “by,” etc.

Text: Modeling Natural Languages

- **Issue 3:** the distribution of words in the documents of a collection
 - The fraction of documents containing a word k time is modeled as a negative binominal distribution

$$F = \binom{\alpha + k - 1}{k} p^k (1 + p)^{-\alpha - k}$$

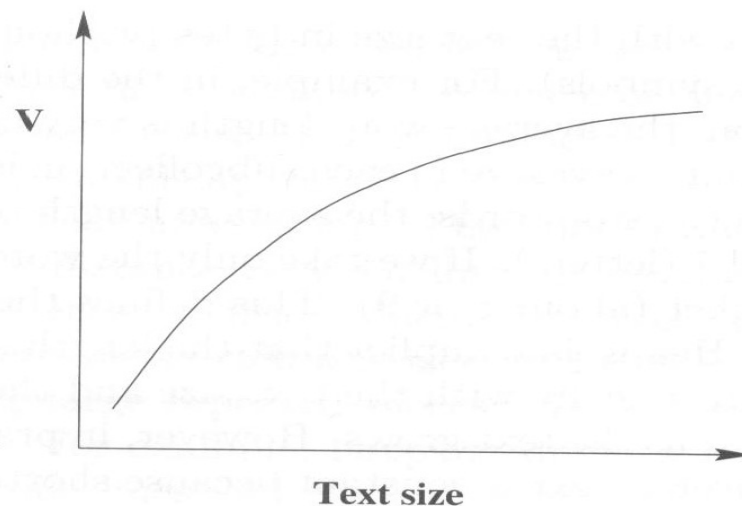
- p and α are parameters that depend on the word and the document collection
 - E.g., $p=9.2$ and $\alpha=0.42$ for the word “said” in the Brown Corpus

Text: Modeling Natural Languages

- **Issue 4:** the number of distinct words in a document (also called “document vocabulary”)

- **Heaps' Law**

- Predict the growth of the vocabulary size in natural language text
- The vocabulary of a text of size n words is of size $V=KN^\beta=O(N^\beta)$
 - K : 10~100
 - β : a positive number less than 1



- Also applicable to collections of documents

Text: Modeling Natural Languages

- **Issue 5: the average length of words**
 - **Heaps' Law**
 - Imply that the length of words of the vocabulary increases logarithmically with the text size
 - Longer and longer words should appear as the text grows
 - However, in practice, the average length of the words in the overall text is constant because shorter words (stopwords) are common enough

Text: Similarity Models

- The syntactic similarity between strings or documents is measured by a distance function

- Should be symmetric $distance(a,b) = distance(b,a)$
- Should satisfy the triangle inequality

$$distance(a,c) \leq distance(a,b) + distance(b,c)$$

- Variant distance functions

- Hamming distance

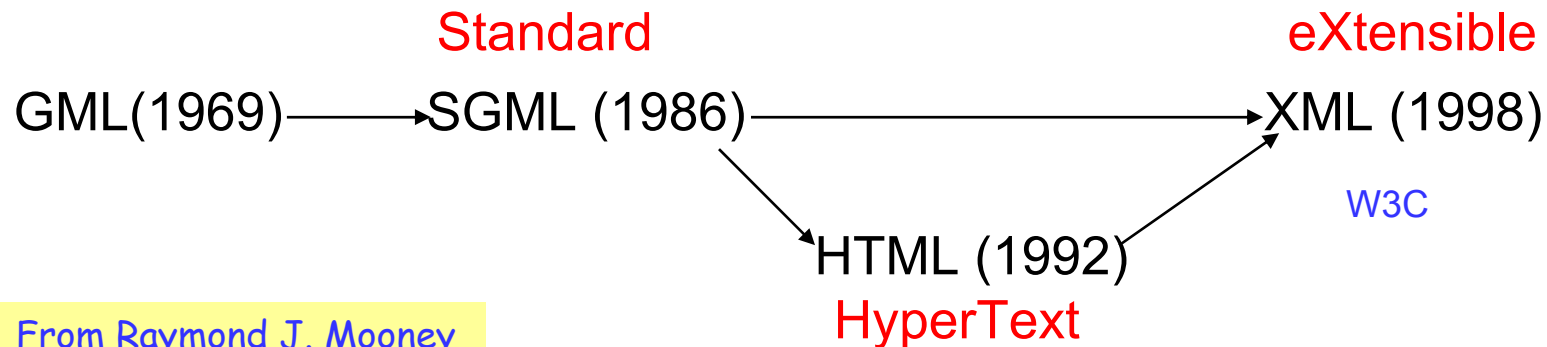
- The number of positions that have different characters between two strings **of the same length**

Text: Similarity Models

- Variant distance functions
 - Edit (or Levenshtein) distance
 - The minimum number of character insertions, deletions, and substitutions needed to perform to make any two strings equal
 - E.g., ‘color’ and ‘colour’, ‘survey’ and ‘surgery’
 - Longest Common Subsequence (LCS)
 - The only allowed operation is deletion of characters
 - Measure the remaining longest common subsequence of both string
 - E.g., ‘survey’ and ‘surgery’ → ‘surey’
- The above similarity measures can be extended to documents
 - Lines in documents are considered as single symbols

Markup Languages

- The extra textual language used to describe formatting actions, structure information, text semantics, attributes, etc Layout of documents
 - Use marks (or called ‘tags’) to surround the marked text
- The standard metalanguage for markup is SGML (Standard Generalized Markup Languages)



SGML

- Document Type Declaration (DTD) in SGML
 - Grammar or schema for defining the tags and structure of a particular document type
 - Allows defining **structure of a document element** using a regular expression
 - Expression defining an **element** can be recursive, allowing the expressive power of a context-free grammar
- A SGML document is defined by
 - **DTD** (a description of the document structure)
 - **The text itself** marked with initial and ending tags for describing the structure

SGML

- Information about document's semantics, application conventions, etc., can be expressed informally as comments
 - DTD does not defined the semantics (meaning, presentation, and behavior), intended use of the tag
 - More complete information is usually present in separation documentation
- SGML does not specify how a doc should look
 - Separate content from format
 - Output specification can be added to SGML documents
 - E.g., Document Style Semantic Specification Language (DSSSL) ,...

```

<!--SGML DTD for electronic messages -->

<!ELEMENT e-mail          - - (prolog, contents) >
<!ELEMENT prolog          - - (sender, address+, subject?, Cc*) >
<!ELEMENT (sender | address | subject | Cc) - 0 (#PCDATA) >
<!ELEMENT contents        - - (par | image | audio)+ >
<!ELEMENT par             - 0 (ref | #PCDATA)+ >
<!ELEMENT ref             - 0 EMPTY >
<!ELEMENT (image | audio) - - (#NDATA) >

<!ATTLIST e-mail
      id          ID          #REQUIRED
      date_sent   DATE        #REQUIRED
      status      (secret | public) public >
<!ATTLIST ref
      id          IDREF       #REQUIRED >
<!ATTLIST (image | audio)
      id          ID          #REQUIRED >

<!--Example of use of previous DTD-->
<!DOCTYPE e-mail SYSTEM "e-mail.dtd">
<e-mail id=94108rby date_sent=02101998>
  <prolog>
    <sender> Pablo Neruda </sender>
    <address> Federico García Lorca </address>
    <address> Ernest Hemingway </address>
    <subject> Pictures of my house in Isla Negra
    <Cc> Gabriel García Márquez </Cc>
  </prolog>
  <contents>
    <par>
      As promised in my previous letter, I am sending two digital
      pictures to show you my house and the splendid view of the
      Pacific Ocean from my bedroom (photo <ref idref=F2>).
    </par>
    <image id=F1> "photo1.gif" </image>
    <image id=F2> "photo2.jpg" </image>
    <par>
      Regards from the South, Pablo.
    </par>
  </contents>
</e-mail>

```

Document Type Declaration (DTD)

A document using DTD

optional (omission of) ending tag

Figure 6.3 DTD for structuring electronic mails and an example of its use.

HTML

- HTML: Hypertext Markup Language
 - An instance of SGML, created in 1992
 - Version 4.0 announced in 1997
- May include code such as Javascript in Dynamic HTML (DHTML)
- Separates layout somewhat by using style sheets (Cascade Style Sheets, CSS)

Visual effects for improving the aesthetics of HTML pages
- HTML primarily defines layout and formatting

XML

- XML: eXtensible Markup Language
 - A simplified subset of SGML
- Simplification of original SGML for the Web promoted by WWW Consortium (W3C)
- Fully separates semantic information and layout
 - Allow a human-readable semantic makeup
- XML impose rigid syntax on the markup
 - Case sensitive
 - Data validation capabilities

XML

- Allow users to define new tags, define more complex structures
- The using of DTD is optional
- Recent uses of XML include
 - Mathematical Markup Language (MathML)
 - Synchronized Multimedia Interchange Language (SMIL)
 - Resource Description Format (RDF)
 - VoiceXML
 - For speech-enabled Web pages
 - Compete with Microsoft SALT (Speech Application Language Tags)

No DTD included

```
<?XML VERSION="1.0" RMD="NONE" ?>
<e-mail id="94108rby" date_sent="02101998">
  <prolog>
    <sender> Pablo Neruda </sender>
    <address> Federico García Lorca </address>
    <address> Ernest Hemingway </address>
    <subject> Pictures of my house in Isla Negra
    <Cc> Gabriel García Márquez </Cc>
  </prolog>
  <contents>
    <par>
      As promised in my previous letter, I am sending two digital
      pictures to show you my house and the splendid view of the
      Pacific Ocean from my bedroom (photo <ref idref="F2"/>).
    </par>
    <image id="F1" ref="photo1.gif" />
    <image id="F2" ref="photo2.jpg" />
    <par>
      Regards from the South, Pablo.
    </par>
  </contents>
</e-mail>
```

For elements without
textual content

Figure 6.5 An XML document without a DTD analogous to the previous SGML example.

Multimedia

- Most common types of media in multimedia applications
 - Text
 - Sound (Speech/Music)
 - Images
 - Video
- These types of media is quite different in
 - Volumes
 - Formats
 - Processing requirements
 - Presentation styles (spatial and temporal attributes)

Multimedia

- Formats
 - Image
 - Bit-mapped (or pixel-based) display
 - XBM, BMP, PCX
 - Simple but consume too much space (redundancy)
 - Compressed Images
 - CompuServe's Graphic Interchange Format (GIF)
 - Lossy Compressed Images
 - » Joint Photographic Experts Group (JPEG)
 - Exchange documents between different applications and platforms
 - Tagged Image File Format (TIFF)
 - True Version Targa Image File (TGA)

Multimedia

- Formats
 - Audio
 - AU, MIDI, WAVE
 - RealAudio, CD formats
 - Video
 - MPEG (Moving Pictures Experts Group), AVI, FLI, QuickTime (by Apple)

Textural Images

- Textural Images: images of documents that contain mainly typed or typeset text
 - Obtained by scanning the documents, usually for archiving purposes
 - Can be used for retrieval purposes and data compression
- Retrieval of Textural Images
 - **Alternative 1**
 - At creation time, a set of keywords (called metadata) is associated with each textual image
 - Conventional text retrieval techniques can be applied to keywords

Textural Images

- Retrieval of Textural Images (cont.)
 - **Alternative 2**
 - Use OCR to extract the text of the image
 - The resultant ASCII text can be used to extract keywords
 - Quality depends on the OCR process
 - **Alternative 3**
 - Symbols extracted from the images are used as basic units to combine image retrieval techniques with sequence retrieval techniques
 - E.g., approximately matching of symbol strings between the query and extracted symbols
 - A promising but difficult issue

Trends and Research Issues

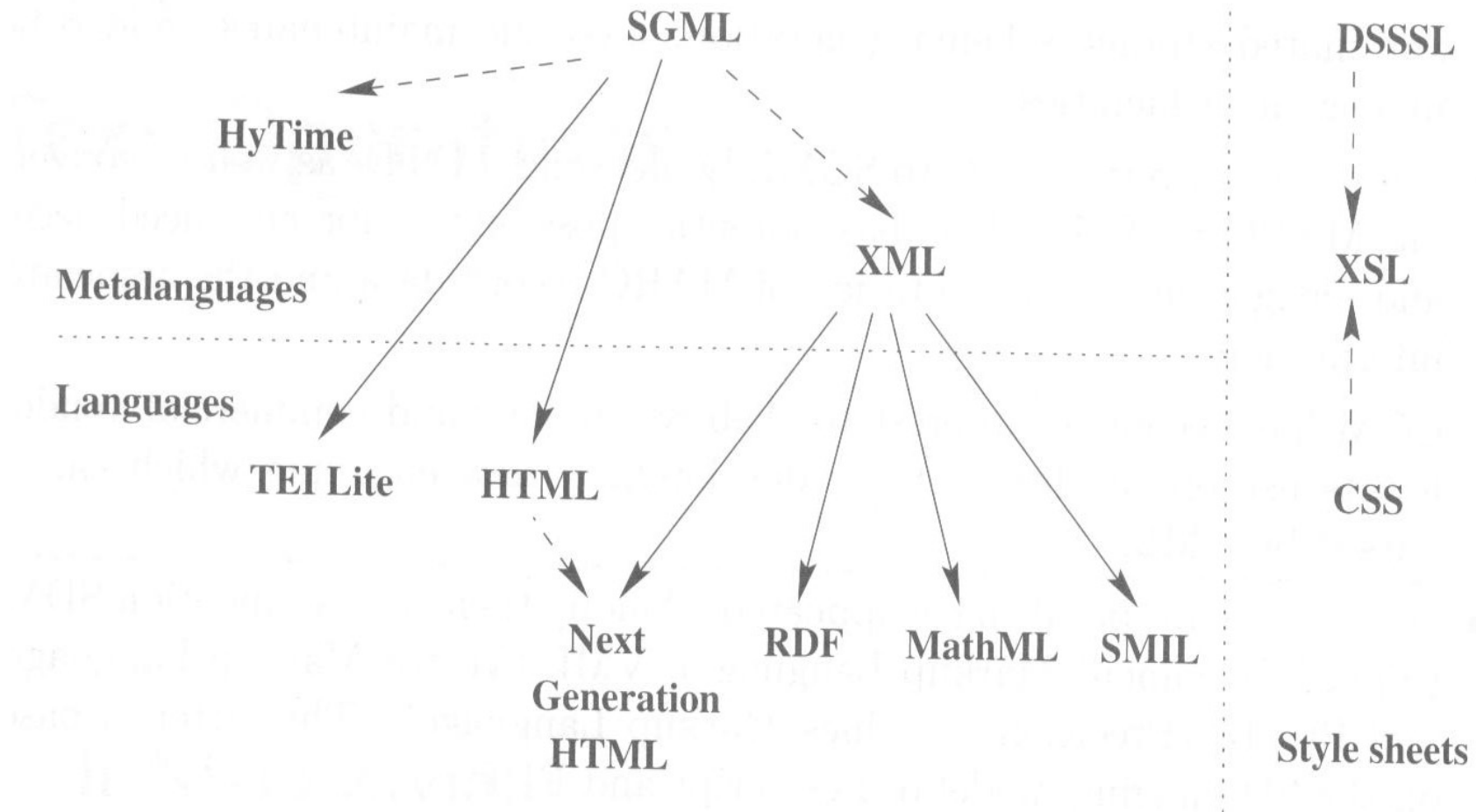


Figure 6.6 Taxonomy of Web languages.