HMIN103
Données du Web

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Slides collected from J. Cheney, S. Abiteboul, I. Manolescu, P. Senellart, P. Genevès, D. Florescu and the W3C

Organisation des TD/TP

- Début des TD/TP (6.07,6.08 dans la limite des places +6.10)

  Groupe 1- AIGLE 6.07 Groupe 2 – DECOL 6.08

- Vendredi + Jeudi (mais, à partir du 10 octobre ☺)
- Jeudi après-midi (avant la toussaints)
  - Pour les inscrits à HMIN121M => 2 séances au vendredi
- Jeudi matin (après la toussaints)
  - Pour les inscrits à HMIN110 => 2 séances au vendredi
- Pas de TD/TP ni CM le 3 (jeudi) et 4 (vendredi) octobre, ni le 26 (jeudi) sept.
- CM 8h à partir de la semaine prochaine (27 sept.)

Rappels du dernier cours

- XML
  - Motivations pour l'introduction du standard
  - Données arborescentes
  - Éléments et attributs
- DTDs
  - Déclarations (ex. HTML : https://www.w3.org/TR/html401/sgml/dtd.html)
  - Intégrité des données : ID / IDRef

Une DTD validant le document ?

```
<D>
  <A/>
  <B>hello</B>
  <C/>
</D>
```

Une DTD validant le document ?

```
<D>
  <A/>
  <B>hello</B>
  <C/>
</D>

<!DOCTYPE D [

 <!ELEMENT D (A,B,C)>

 <!ELEMENT A (#PCDATA)>
 <!ELEMENT B (#PCDATA)>
 <!ELEMENT C (#PCDATA)>   ]>
```

Une DTD validant le document ?

```
 <D>
   <A/>
   <B>hello</B>
   <C/>
 </D>

<!DOCTYPE D [

 <!ELEMENT D (A*,B,C,D?)>

 <!ELEMENT A EMPTY>
 <!ELEMENT B (#PCDATA)>
 <!ELEMENT C ANY>   ]>
```

Une DTD validant le document ?

```
<C>
    <C id=”p4” friend=”p4”>Alice</C>
    <C id=“p1” friend=”p2”>Bob</C>
    <C id=“p2” friend=”p0”>Alice</C>
</C>
```

Une DTD validant le document ?

```
<C>

    <C id=”p4” friend=”p4”>Alice</C>

    <C id=“p1” friend=”p2”>Bob</C>

    <C id=“p2” friend=”p0”>Alice</C>

</C>
```

```
               <!DOCTYPE C [    <!ELEMENT C (C*)>

               <!ATTLIST id ID CDATA  IMPLIED>

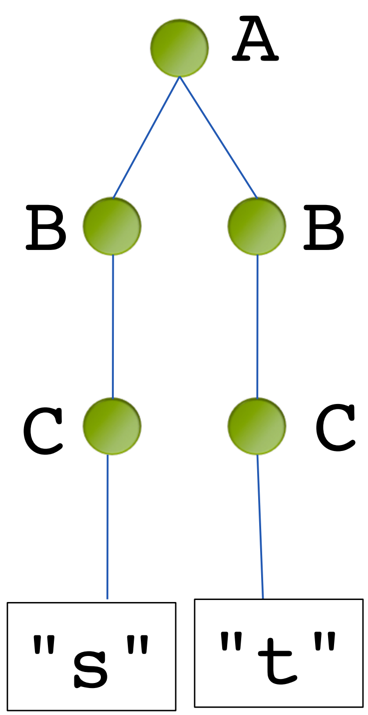
               <!ATTLIST C friend IDREF CDATA>   ]>
```

Un document valide pour la DTD ?

```
<! DOCTYPE A [
   <! ELEMENT A (B,B) >
   <! ELEMENT B (C) >
   <! ELEMENT C (#PCDATA) >
  ]>
```

Un document valide pour la DTD ?

```
<! DOCTYPE A [
   <! ELEMENT A (B,B) >
   <! ELEMENT B (C) >
   <! ELEMENT C (#PCDATA) >
  ]>
```



Un document valide pour la DTD ?

```
<! DOCTYPE B [
 <! ELEMENT B (A,C)
 <! ELEMENT C (D)
 <! ELEMENT A (D)
  <! ELEMENT C (#PCDATA) >
  <! ELEMENT D (#PCDATA) >
 ]>
```

Un document valide pour la DTD ?

```
<! DOCTYPE A [

 <! ELEMENT A (B) >
 <! ELEMENT B (A) >

]>
```

Un document valide pour la DTD ?

```
<! DOCTYPE C [

  (! ELEMENT C (C*) )

 ]>
```

Un document valide pour la DTD ?

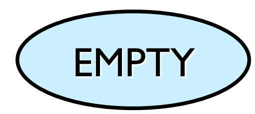
```
<! DOCTYPE EMPTY [

 <! ELEMENT EMPTY EMPTY >

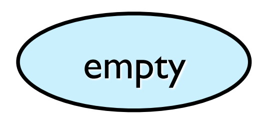
]>
```

Un document valide pour la DTD ?

```
<! DOCTYPE EMPTY [
  <! ELEMENT EMPTY EMPTY >
]>
```




```
<! DOCTYPE empty [
  <! ELEMENT empty EMPTY >
]>
```



Un document valide pour la DTD ?

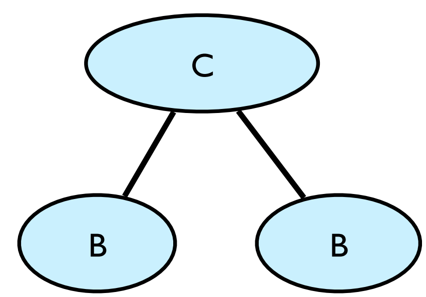
```
<! DOCTYPE C [

 <! ELEMENT C (B* | (C, C, C, C)) >

]>
```

Un document valide pour la DTD ?

```
<! DOCTYPE C [
  <! ELEMENT C (B* | (C, C, C, C)) >
]>
```



Un document valide pour la DTD ?

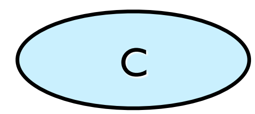
```
<! DOCTYPE C [
 <! ELEMENT C (C,EMPTY)? >
]>
```

Un document valide pour la DTD ?

```
<! DOCTYPE C [

 <! ELEMENT C (C,EMPTY)? >

]>
```



Un document valide pour la DTD ?

```
<!DOCTYPE ANY [

<!ELEMENT ANY ANY>

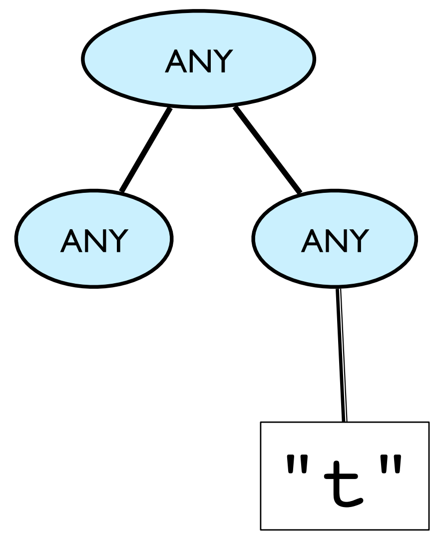
]>
```

Un document valide pour la DTD ?

```
<!DOCTYPE ANY [

<!ELEMENT ANY ANY>

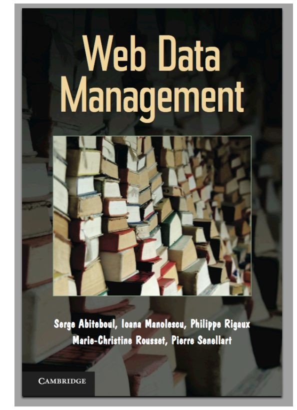
]>
```



DTDs and Regular Tree Grammars

(fun with regular expressions)

Readings



- Web Data Management - Abiteboul & al.
- [WDM-XML] Chapter : Data-model
  - http://webdam.inria.fr//Jorge/files/wdm-datamodel.pdf
- [WDM-DTD] Chapter : Schemas (only section 3)
  - http://webdam.inria.fr//Jorge/files/wdm-typing.pdf

Schemas for XML Data

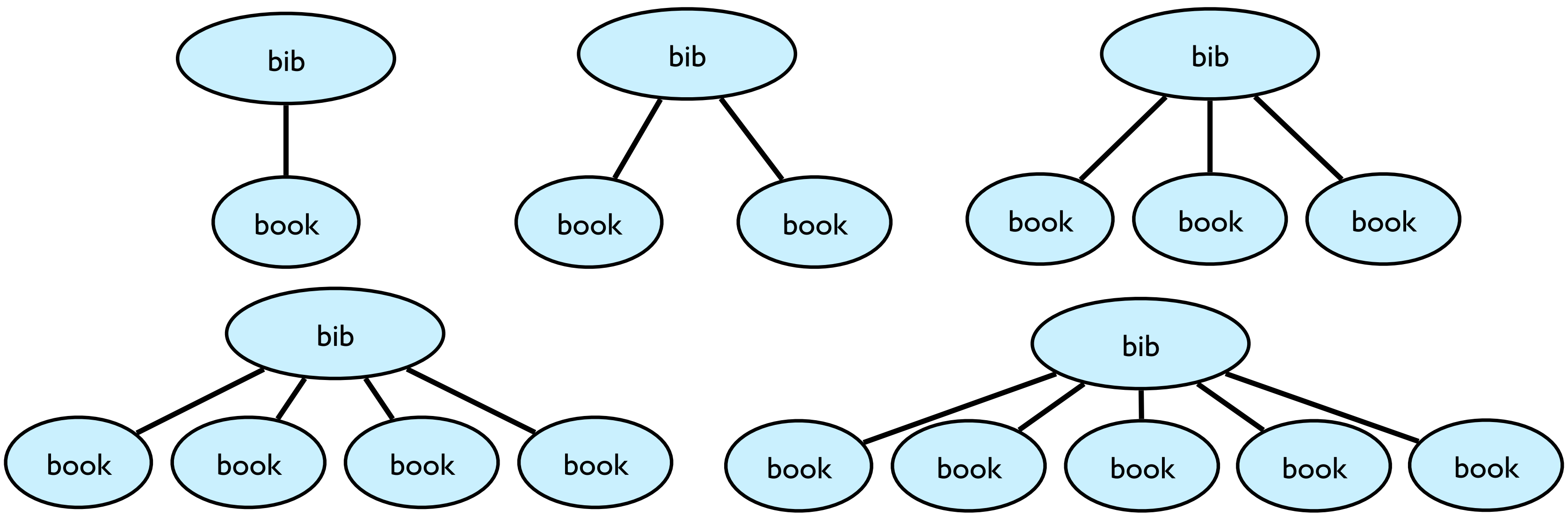
- Many schema languages/formalisms have been proposeed
  - DTD (XML 1.0)
  - XML Schema (W3C)
  - Relax/NG (OASIS), DSD, Schematron, ...
  - Regular expression types (XDuce, XQuery)

- Every XML schema language is based on regular expressions and grammars.
  - This illustrates an important use of theory in real applications.

Regular Tree Grammars

A DTD defines a (possibly infinite) set of **regular** XML trees.

```
<!ELEMENT bib book+>        <!ELEMENT book EMPTY>
```



Plan

- Grammars
- Validation
- Determinism

Grammars (context-free)

Sets of rules used to specify a formal language (of words).

```
S -> PQ          P -> aP|a          Q -> b
```

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```
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```

```
ab

aab

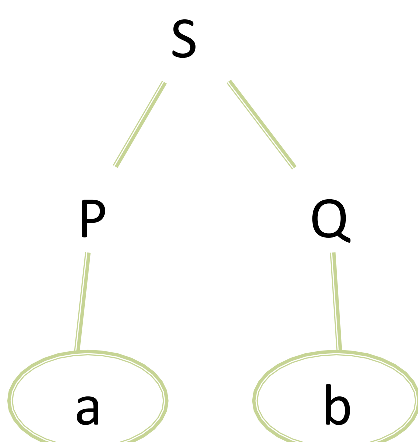
aaab

aaaab
```

Grammars (context-free)

Sets of rules used to specify a formal language (of words).

`S -> PQ`   `P -> aP|a`   `Q -> b`

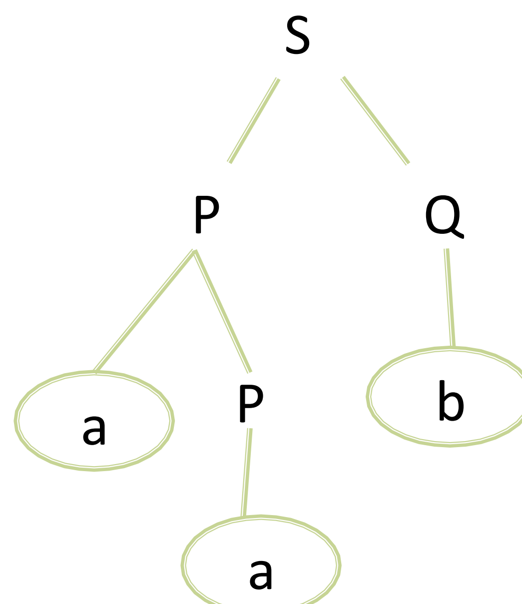


`ab`

`aab`

`aaab`

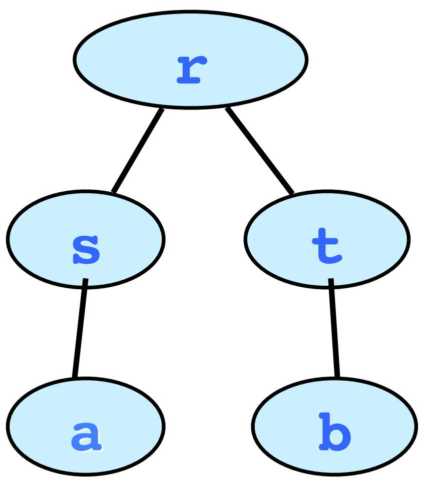
`aaaab`



Tree Grammars

Sets of rules used to specify a formal language of trees.

```
S -> r[PQ]          P -> s[a]          Q -> t[b]
```



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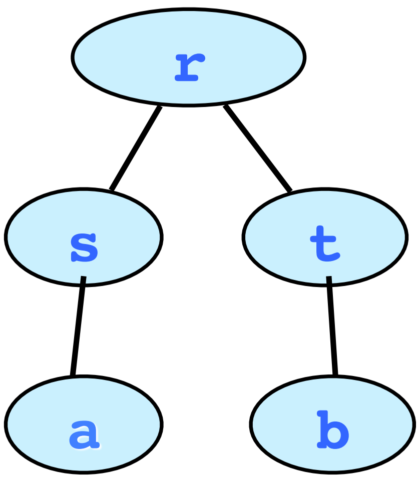
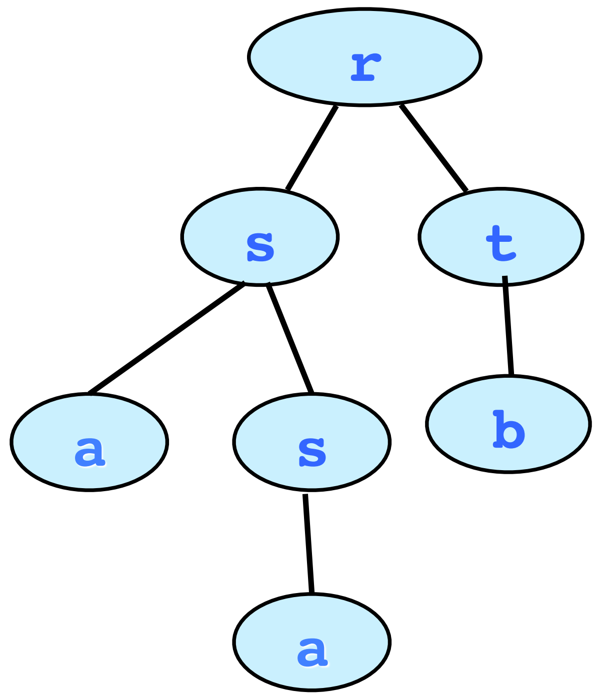


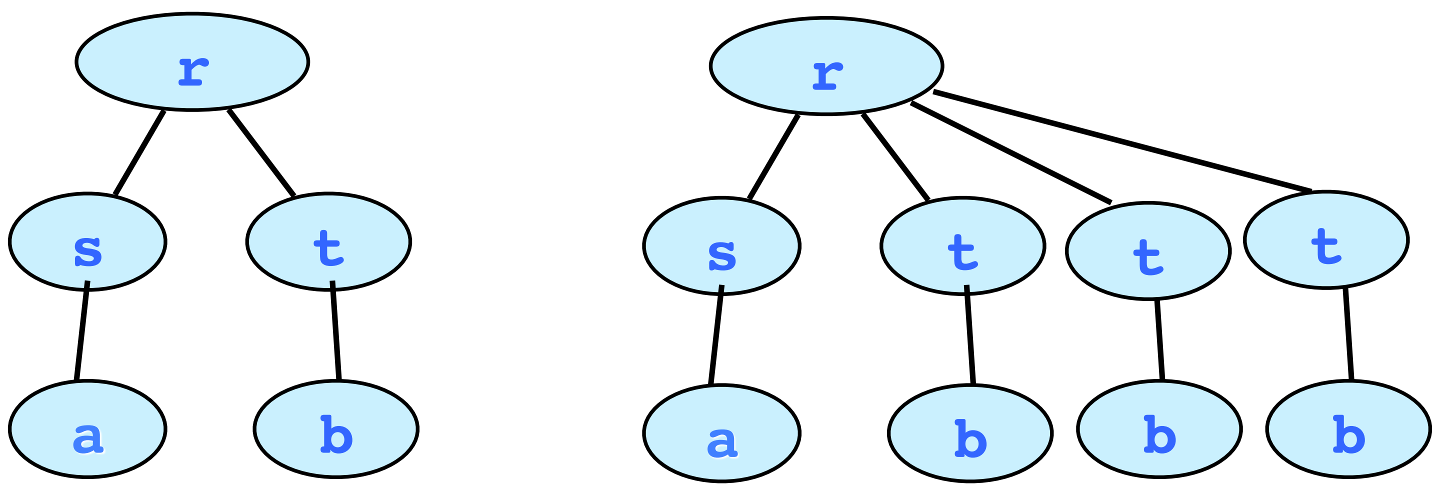


Vertical recursion

Tree Grammars

Sets of rules used to specify a formal language of trees.

`S -> r[PQ]`   `P -> s[a]`   `Q -> t[b],Q |t[b]`

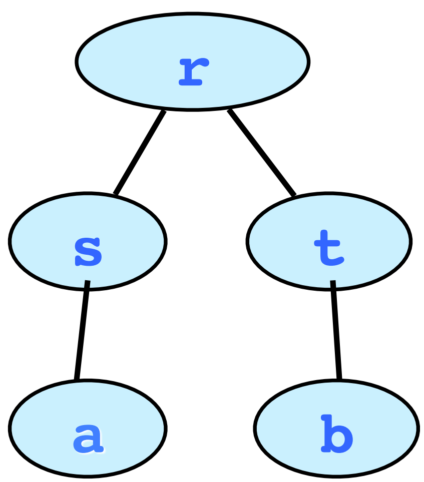


Horizontal recursion

Regular Tree Grammars

Sets of rules used to specify a formal regular language of trees.

```
S -> r[P,Q]        P -> s[aP|a]        Q -> t[b],Q |t[b]
```



Forbid certains uses of horizontal recursion

```
Q -> t[b],Q        OK

Q -> Q,t[b],Q      NO
```

(analogous to the definition of regular word grammars)

Regular Tree Grammars

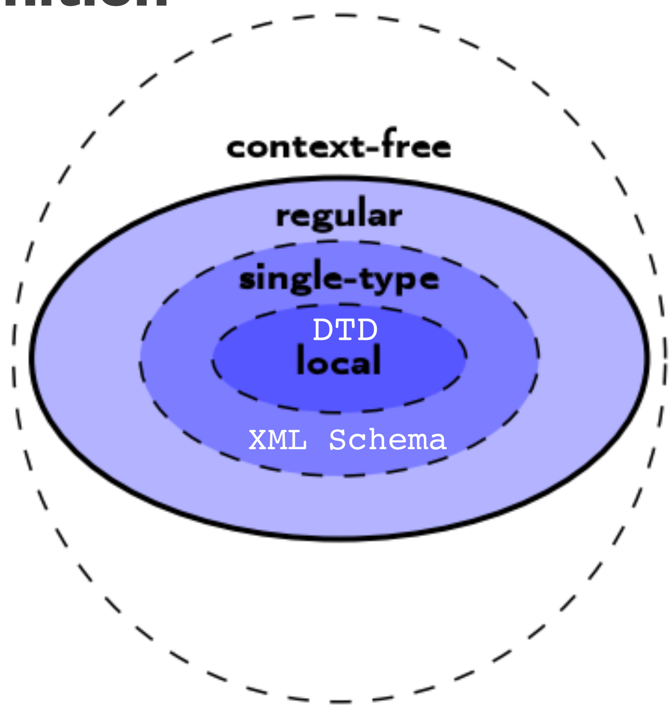
DTD are a subclass of regular tree-grammars called “**local**” :

any element has at most one definition

<!ELEMENT root child*>

<!ELEMENT child (#PCDATA)>

~~<!ELEMENT child EMPTY>~~



Why Regular Tree Grammars ?

- Regular Tree Grammars are expressive enough, and computationally more easy to handle than context-free
  - To illustrate, the following problems for context-free **tree** grammars <u>cannot be algorithmically solved</u> :
    - determine wether a context-free grammar is actually a regular grammar
    - determine wether a context-free grammar G1 is more general than (or, "includes") a context-free grammar G2

XML VALIDATION

Document Validation

- Problem : is an XML document valid with respect to a given DTD ?

Validation Algorithm

- Traverse XML tree in pre-order (document order) & check:

1. that each node is valid
2. that each attribute (of a node) is valid
3. the id-unicity and idref-references

Validation Algorithm

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Validation Algorithm

- Traverse XML tree in pre-order and check

1. that each node is valid

   more interesting

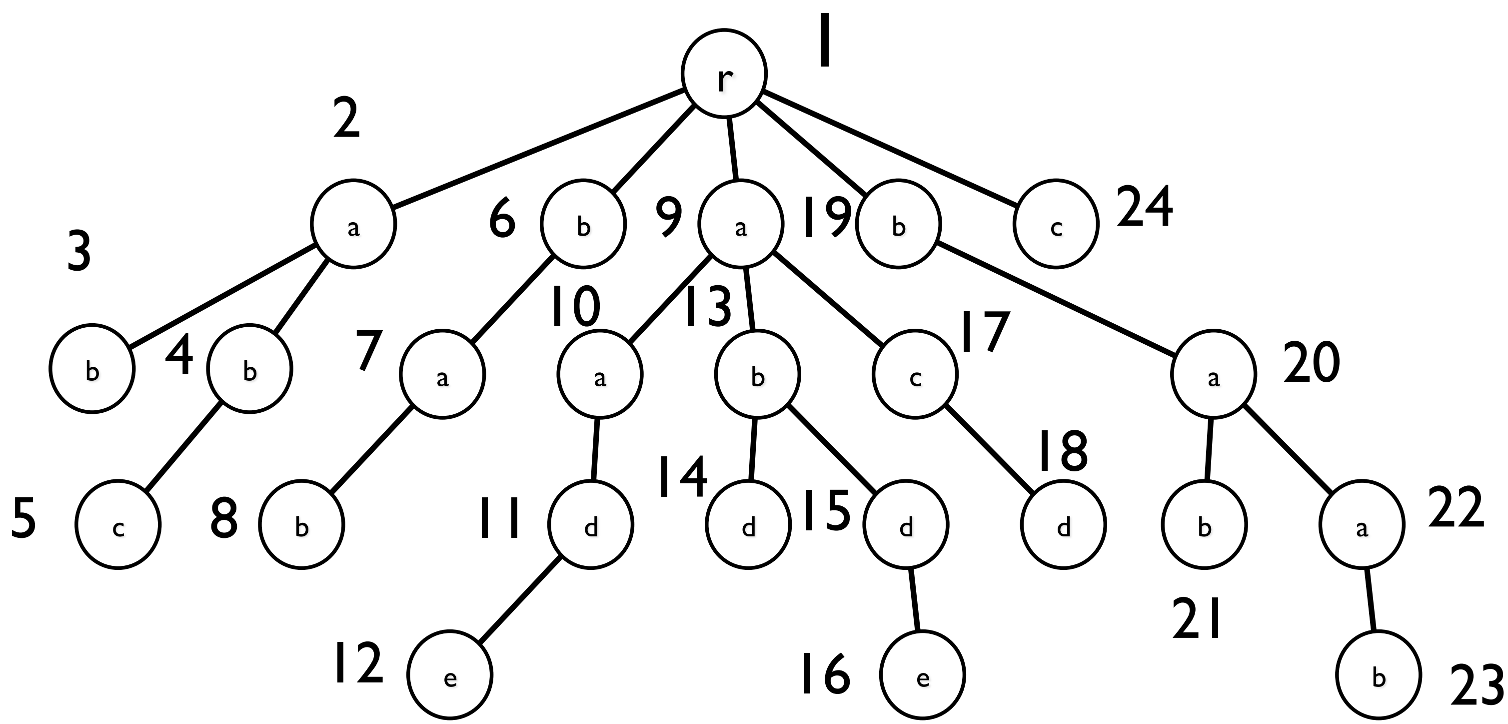
2. that each attribute (of a node) is valid

   trivial

3. the id-unicity and idref-references

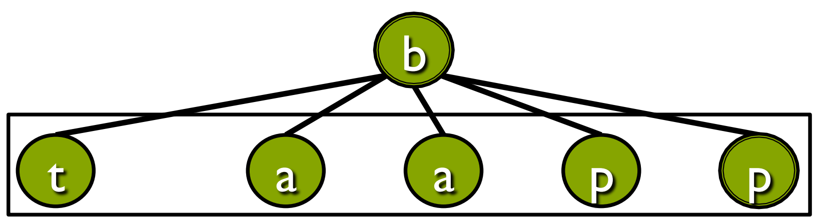
   easy

Pre-order Traversal



(Single Node) Validation

- Problem : does the sequence of children of the node match the regular expression specified by the DTD ?



Regular expressions

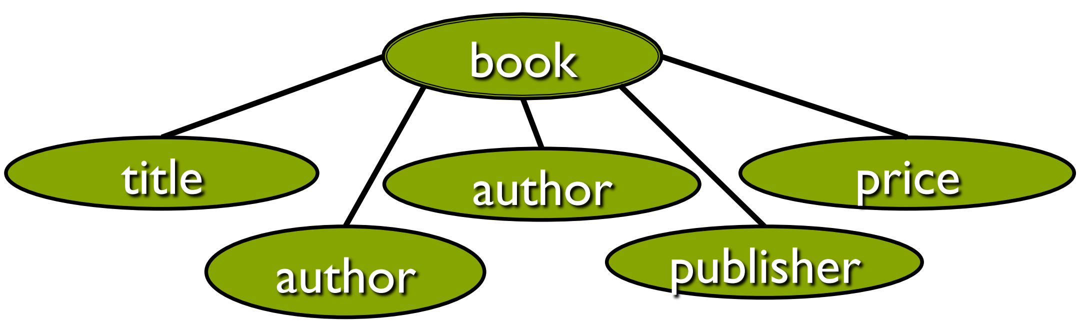
`r ::=`	ϵ	empty sequence
`|`	`a`	atomic symbol (in DTD, an element name)
`|`	`(r,s)`	sequential composition
`|`	`(r|s)`	union (alternation)
`|`	`(r+)`	repetition

`r* = r+|`ϵ `r? = r|`ϵ

Example

The regular expression for a book node is

```
(title, (author+ | editor+ ), publisher, price )
```



Example

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```
(title, (author+ | editor+ ), publisher, price )
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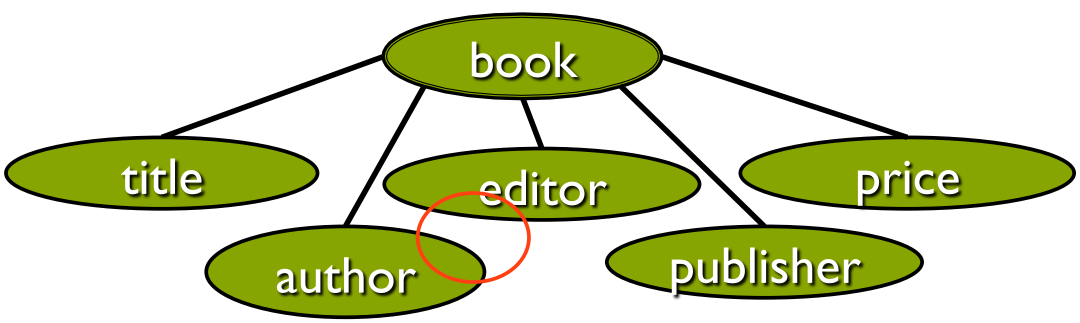


DETERMINISM

W3C Restriction

- Can we write any regular expression in a DTD ?
- NO.

- Regular expressions in DTDs must be deterministic:
  - *"there must be only one way to match any sequence of tags, no backtrack or look-ahead is required"*
- This is equivalent to say that the automata corresponding to the regular expression is <u>deterministic</u>.
- This eases the validation process, and makes it doable in <u>streaming</u>

Example of Ambiguity

`( title, author* ) | ( title , editor* )` **NO**

can't decide if `<title/>` matches first or second "`title`"

Better to write `title , ( author* | editor* )`

How to test Determinism?

- Simplified algorithm

- Ingredients : three auxiliary functions

FirstTag() LastTag() FollowsTag()

(1/3) FirstTag

*What can be the **first** tag of a sequence matching r ?*

r_1 = `(title, (author+ | editor+ ), publisher, price )`

FirstTag(r_1) ? `title`

r_2 = `(author+ | editor+ )`

FirstTag(r_2) ? `author, editor`

(2/3) LastTag

*What can be the **last** tag of a sequence matching r ?*

r_1 = `(title, (author+ | editor+ ), publisher, price )`

LastTag(r_1) ? `price`

r_2 = `(author+ | editor+ )`

LastTag(r_2) ? `author, editor`

(3/3) FollowsTag

What tag can follow x in r ?

r_1 = `(title, (author+ | editor+ ), publisher, price )`

FollowsTag(r_1 , `title`) ? `author, editor`

r_4 = `(author | editor )*`

FollowsTag(r_4 , `author`) ? `author, editor`

Disambiguation

r_5 = `(author, title)? , author`

We resolve ambiguity by enumerating the tag occurrences

$r_5^\#$ = $\texttt{(author}_1\texttt{, title)? , author}_2$

FirstTag($r_5^\#$) = $\texttt{author}_1\texttt{, author}_2$

LastTag($r_5^\#$) = $\texttt{author}_2$

FollowsTag($r_5^\#$, `title`) = $\texttt{author}_2$

Determinism Algorithm

1) Enumerate all the occurrences of a tag in r

2) Build a graph were

- there is a node x for each tag in ($r^{\#}$), plus a source-node x_0

- there is a directed edge (x_0,y) if y belongs to FirstTag($r^{\#}$)

- there is a directed edge (x,y) if y belongs to FollowsTag($r^{\#}$,x)

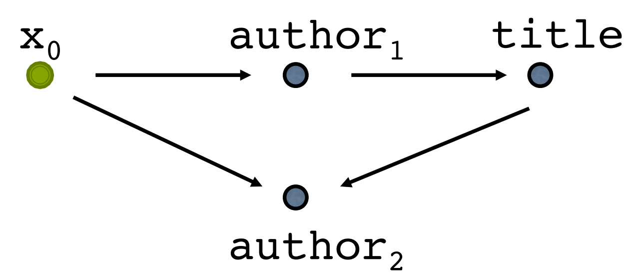
3) return **false** if there exists edges (x,y_i) and (x,y_j) with $i \neq j$

4) return **true** otherwise

Testing Determinism

r_5 = `(author, title)? , author`

$r_5^{\#}$ = $(\texttt{author}_1, \texttt{title})? , \texttt{author}_2$



$\text{FirstTag}(r_5^{\#}) = \texttt{author}_1, \texttt{author}_2$

$\text{FollowsTag}(r_5^{\#}, \texttt{author}_1) = \texttt{title}$

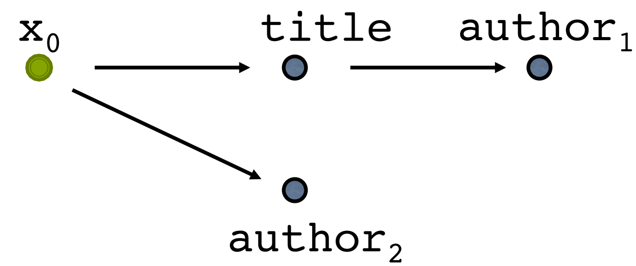
$\text{FollowsTag}(r_5^{\#}, \texttt{title}) = \texttt{author}_2$

r_5 not deterministic

Testing Determinism

r_6 = `(title, author) | author`

$r_6^{\#}$ = $(\texttt{title}, \texttt{author}_1) \mid \texttt{author}_2$



FirstTag($r_6^{\#}$) = $\texttt{title}, \texttt{author}_2$

FollowsTag($r_6^{\#}$,title) = $\texttt{author}_1$

r_6 deterministic

Determinism - Quiz

Are the following regular expressions deterministic ?

- `((e|cb),b)*((cc|b)e,d)*`
- `(a,(ab|c))|(b,(a|c))`

Why did we define **LastTag**(r) afterall ?

- It is hidden behind the definition of FollowsTag(r,x)

FirstTag()

Definition on the structure of the regular expression

- FirstTag(ϵ) = {}
- FirstTag(`a`) = { `a` }
- FirstTag(`r|s`) = firstTag(`r`) U firstTag(`s`)
- FirstTag(`r*`) = firstTag(`r`)
- FirstTag(`r,s`) = firstTag(`r`)

FirstTag()

Definition on the structure of the regular expression

- FirstTag(ϵ) = {}
- FirstTag(`a`) = { `a` }
- FirstTag(`r|s`) = ?
- FirstTag(`r*`) = ?
- FirstTag(`r,s`) = ?

FirstTag()

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- FirstTag(`r`*) = firstTag(`r`)
- FirstTag(`r`,`s`) = firstTag(`r`) [U firstTag(`s`) IF `r` matches ϵ]

LastTag()

Definition on the structure of the regular expression

- LastTag(ϵ) = ?
- LastTag(a) = ?
- LastTag(r | s) = ?
- LastTag(r*) = ?
- LastTag(r , s) = ?

LastTag()

Definition on the structure of the regular expression

- LastTag(ϵ) = {}
- LastTag(a) = { a }
- LastTag(r | s) = LastTag (r) U LastTag (s)
- LastTag(r*) = LastTag(r)
- LastTag(r , s) = LastTag (s)   [U LastTag(r) IF s matches ϵ]

FollowsTag()

Definition on the structure of the regular expression

- FollowsTag(ϵ) = ?
- FollowsTag(`a`) = ?
- FollowsTag(`r` | `s`) = ?
- FollowsTag(`r*`) = ?
- FollowsTag(`r` ,`s`) = ?

FollowsTag()

Definition on the structure of the regular expression

- FollowsTag(ϵ) = {}
- FollowsTag(`a`) = { }
- FollowsTag(`r` | `s`) = FollowsTag (`r`) U FollowsTag (`s`)
- FollowsTag(`r*`) = FollowsTag (`r`, `r`)
- FollowsTag(`r` ,`s`) = FollowsTag (`r`) U FollowsTag (`s`)

  U LastTag(`r`) x FirstTag(`s`)

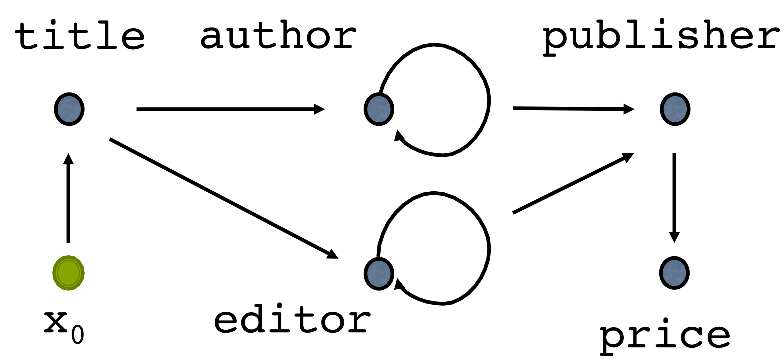
... now back to Node Validation

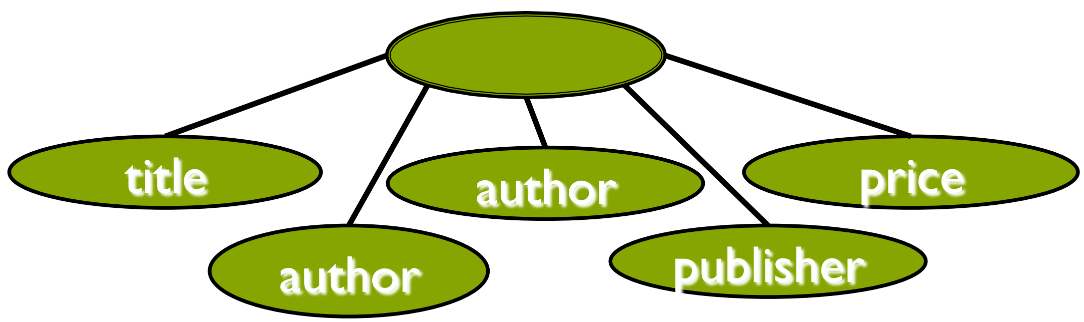
good news : this comes almost for free now!

- `check if the sequence defines a path`
  `in the graph which ends on a LastTag(r`$^{\#}$`)`

Sequence Validation

r = `(title, (author+ | editor+ ), publisher, price )`

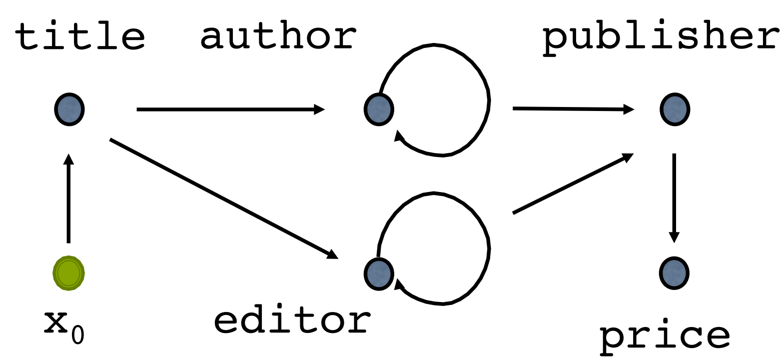


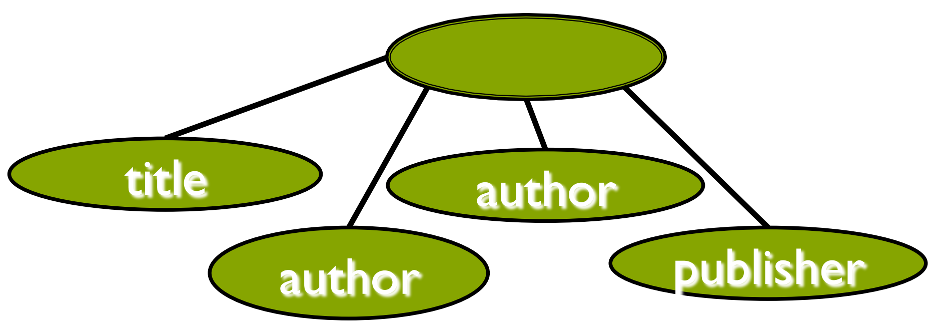


OK

Sequence Validation

`r = (title,  (author+ | editor+ ), publisher, price )`

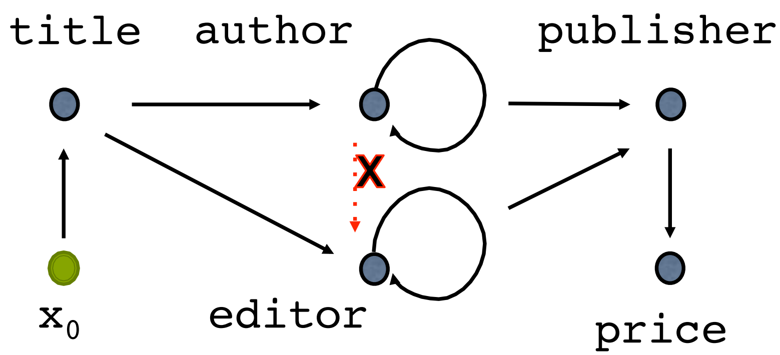


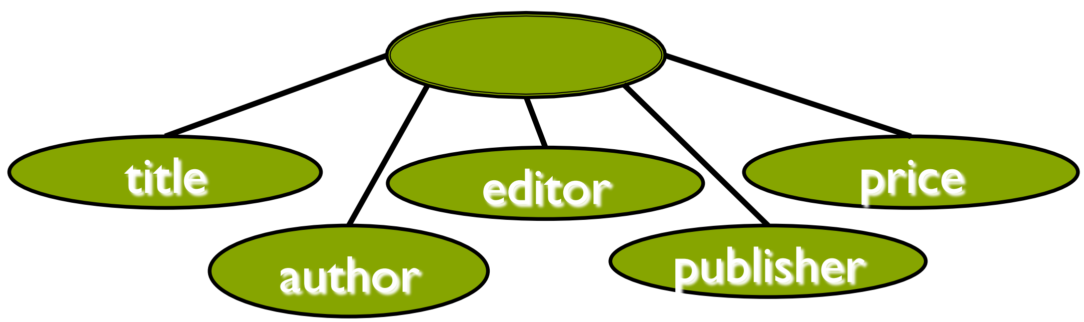


NO

Sequence Validation

r = `(title, (author+ | editor+ ), publisher, price )`



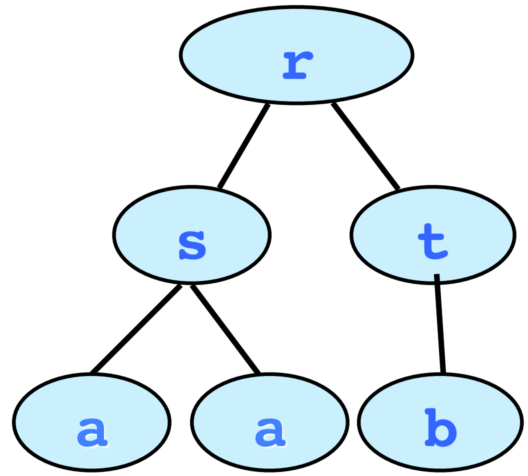


NO

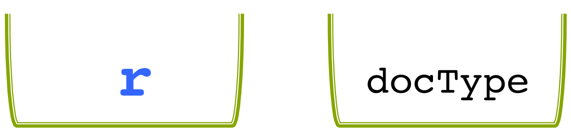
Document Validation Algorithm

- set **last** := root ; stackDTD.push(docType)
- for every node **n (!= root)** taken in a pre-order visit of the tree
- if **last** is the parent of **n** //moving down parent -> child
  - create new list **L** ; add n to **L**
  - stackXML.push(**L**) ; stackDTD.push(typeDTD(**last**))
- if n is the last of its siblings //next move up child -> parent
  - stackXML.top.add(**n**)
  - stackXML.top.isValid(stackDTD.top())
  - stackXML.pop() ; stackDTD.pop() //empty buffers
- else //move left child -> sibling
  - stackXML.top.add(**n**)

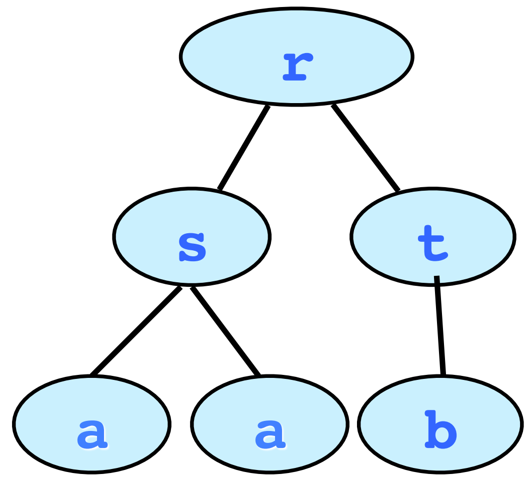
Validation Example

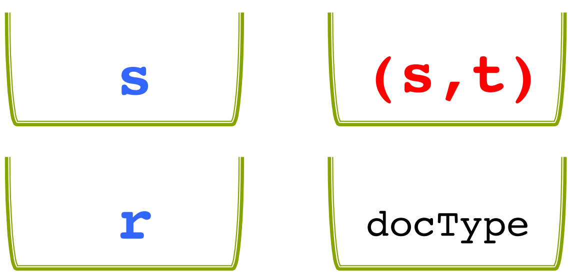



```
<!DOCTYPE r [
<!ELEMENT r (s,t)>
<!ELEMENT s (a*)>
<!ELEMENT t (b?)>
]>
```



Validation Example



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<!ELEMENT r (s,t)>
<!ELEMENT s (a*)>
<!ELEMENT t (b?)>
]>
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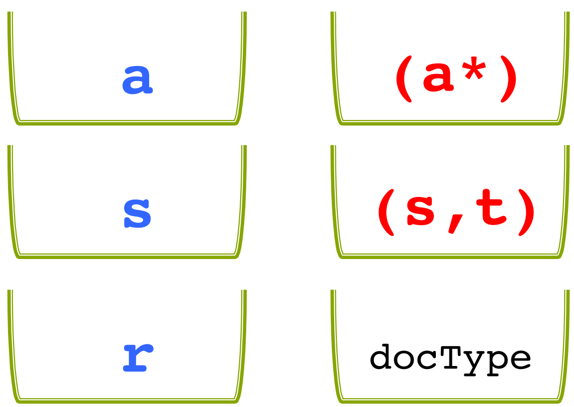
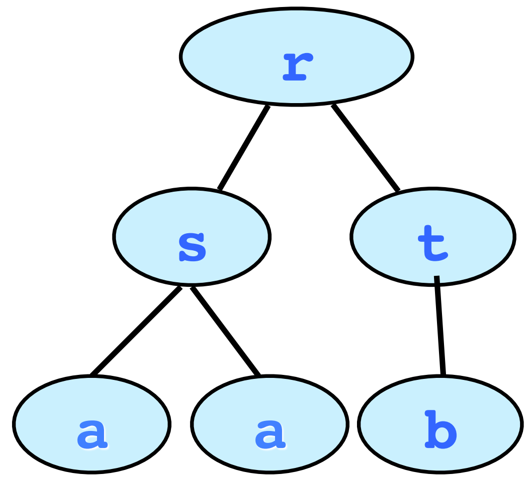
Validation Example



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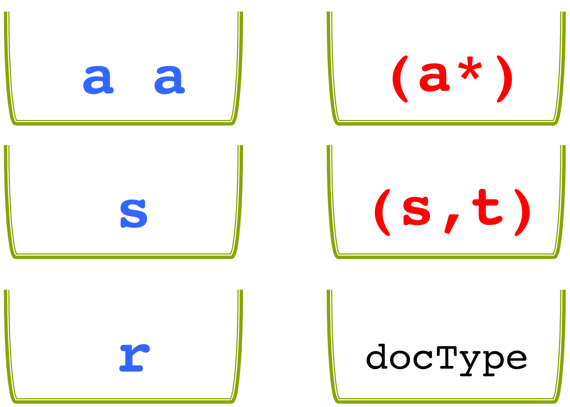

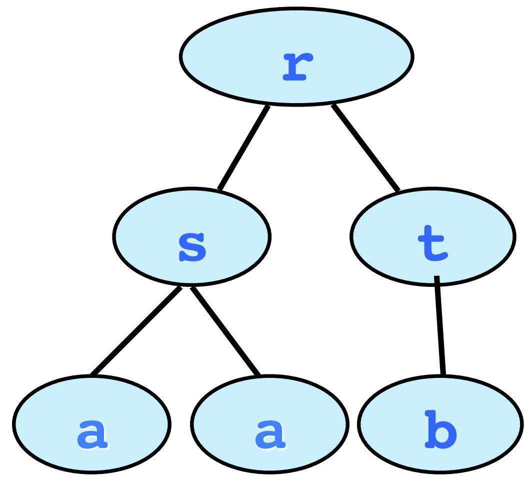


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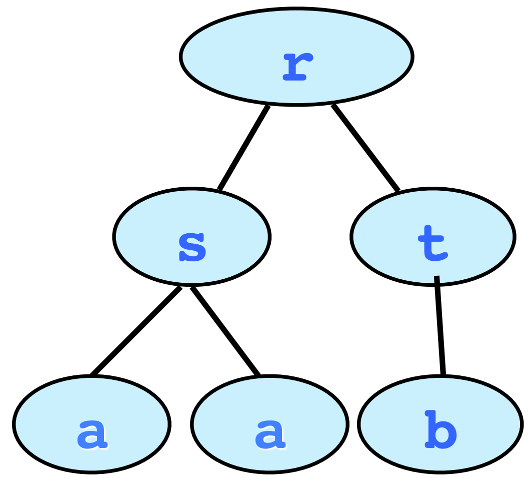

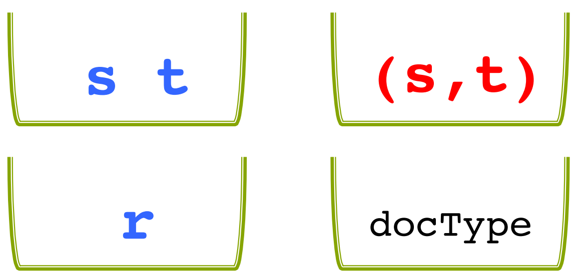


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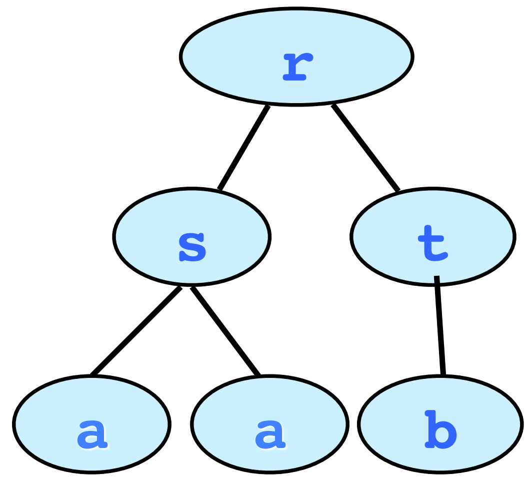

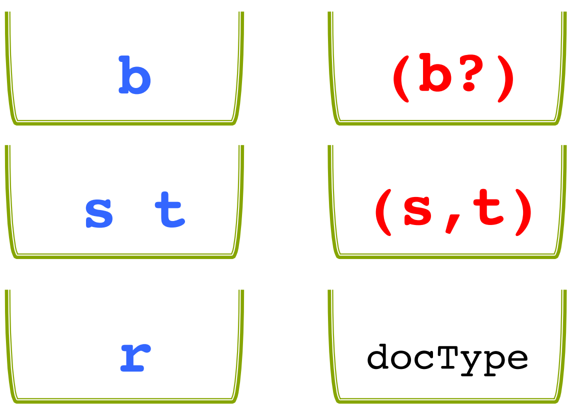


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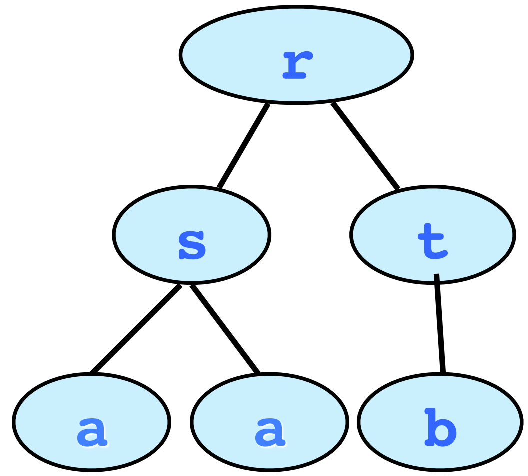


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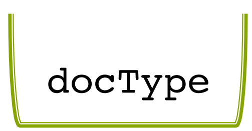

Research Highlights

Checking Determinism

- Quadratic algorithm [Brueggemann-Klein]
- (best) Linear algorithm [Groz, Staworko, Maneth '11]

Checking Validity

- (best) Sublinear space algorithm [Konrad, Magniez '11]