Applied Databases

Lecture 19
Recap I

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University of Edinburgh - March 27th, 2017

Recap I & II

1. XML, DTDs, XPath, deterministic regex's
2. Schemas, Normal Forms, SQL
3. TFIDF-ranking, string matching (KMP, automata, Boyer-Moore)

1. XML

(1) well-formedness

For each of the following, explain whether or not it is well-formed XML.
In case it is not well-formed, list all violations that you find.
Say for each violation whether it is context-free or context-dependent.

a) `<comment>For numbers x with x<>5, x/5 is not 1.</comment>`
b) `<auto<node>>XF23414</auto<node>>`
c) `<b><b><b at=”7”/><b at=”7”><b/></b><b/></b at=”4”></b>`
d) `<a a=”a”/>`
e) `<a><a/><b></b><c></c>`
f) `<a b3=”a” b2=”b” b1=”a” b2=”5”/>`

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c) not well-formed. at=”4” not allowed in an end tag → context-free

XML Grammar - EBNF-style


```
[1]   document    ::=   prolog element Misc*
[2]       Char    ::=   a Unicode character
[3]          S    ::=   (‘ ’ | ‘\t’ | ‘\n’ | ‘\r’)+
[4]   NameChar    ::=   (Letter | Digit | ‘.’ | ‘-’ | ‘:’)
[5]       Name    ::=   (Letter | '_' | ':') (NameChar)*

[22]    prolog    ::=   XMLDecl? Misc* (doctypedecl Misc*)?
[23]   XMLDecl    ::=   '<?xml' VersionInfo EncodingDecl? SDDecl? S? '?>‘
[24]VersionInfo   ::=   S'version'Eq("'"VersionNum"'"|'"'VersionNum'"')
[25]        Eq    ::=   S? '=' S?
[26]VersionNum    ::=   '1.0‘

[39]   element    ::=   EmptyElemTag
                      | STag content Etag
[40]       STag   ::=   '<' Name (S Attribute)* S? '>'
[41] Attribute    ::=   Name Eq AttValue
[42]       ETag   ::=   '</' Name S? '>‘
[43]    content   ::=   (element | Reference | CharData?)*
[44]EmptyElemTag  ::=   '<' Name (S Attribute)* S? '/>‘

[67] Reference    ::=   EntityRef | CharRef
[68] EntityRef    ::=   '&' Name ';‘
[84] Letter       ::=   [a-zA-Z]
[88] Digit        ::=   [0-9]
```

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b) not well-formed. Symbol “<” cannot appear inside a tag-name. → context-free

c) not well-formed. at=”4” not allowed in an end tag → context-free
d) well-formed.

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d) well-formed.

e) not well-formed. Missing end tag for first <a>-tag → context-free

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This is specified in the XML grammar → context-free
b) not well-formed. Symbol “<” cannot appear inside a tag-name. → context-free
c) not well-formed. Two violations:
(1) no end-tag for first <b>-tag → context-free (!)
(2) at=”4” not allowed in an end tag → context-free
d) well-formed.
e) not well-formed. Missing end tag for first <a>-tag → context-free
f) not well-formed. Duplicate attribute (b2) → context-dependent

(2) DTDs

Which of the following are well-formed wrt the given DTD.
List all violations that you find.

```
<!DOCTYPE bib [
<!ELEMENT bib (book | journal)*>
<!ELEMENT book (author, title)>
<!ELEMENT journal (author, title, cites?)>
<!ELEMENT cites (book | journal)*>
<!ELEMENT author (#PCDATA)>
<!ELEMENT title (#PCDATA)>
<!ATTLIST book isbn ID #REQUIRED>
]>
```

a) `<bib><book></book></bib>`

b) `<bib><journal isbn="xyz"><author/><title/></journal></bib>`

c) `<bib><book isbn="123"><author/><title/></book><journal><author/>`
`<title/><cites><book isbn="123"><author/><title/><book/></cites></journal></bib>`

d) `<bib book="isbn"></bib>`

e) `<bib>no entries</bib>`

f) `<bib></bib><bib></bib>`

g) `<bib><author></author><title></title></Bib>`

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```

a) `<bib><book></book></bib>`

→ not well-formed!

(1) book must have `author` and `title` children

(2) book must have `isbn` attribute

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b) `<bib><journal isbn=”xyz”><author/><title/></journal></bib>`

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```

b) `<bib><journal isbn="xyz"><author/><title/></journal></bib>`

→ not well-formed!

attribute `isbn` not declared for `journal` element

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Which of the following are well-formed wrt the given DTD.
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c) <bib><book isbn=”123”><author/><title/></book><journal><author/>
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c) <bib><book isbn="123"><author/><title/></book><journal><author/>
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→ not well-formed!

Two violations: (1) end-tag of 2nd book-tag does not match (context-sensitive)
(2) ?

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c) `<bib><book isbn="123"><author/><title/></book><journal><author/>`
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→ not well-formed!

Two violations: (1) end-tag of 2nd book-tag does not match (context-sensitive)
(2) isbn-attribute of type ID has repeating values

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Which of the following are well-formed wrt the given DTD.
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d) `<bib book="isbn"></bib>`

→ not well-formed!

attribute `book` not declared for `bib` element

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e) `<bib>no entries</bib>`

→ not well-formed!

`bib`-content must be `(book | journal)*`, so cannot be #PCDATA

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f) `<bib></bib><bib></bib>`

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f) `<bib></bib><bib></bib>`

→ not well-formed!
no root node (must end after first </bib>) context-free

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g) `<bib><author></author><title></title></Bib>`

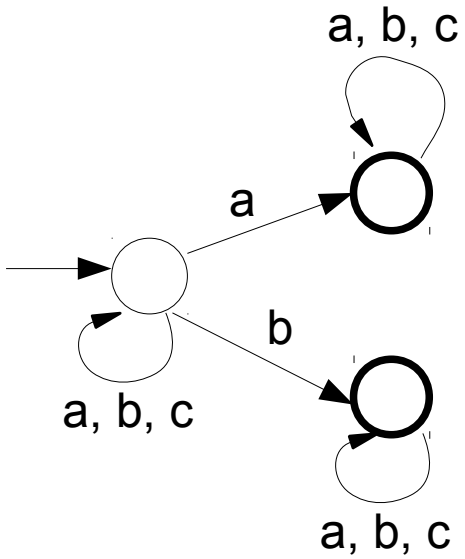
→ not well-formed!

Two violations:

(1) `Bib` does not match start `bib`-tag context-dependent

(2) `bib` may not have `author` or `title` children context-free

(2) Deterministic Regular Expressions



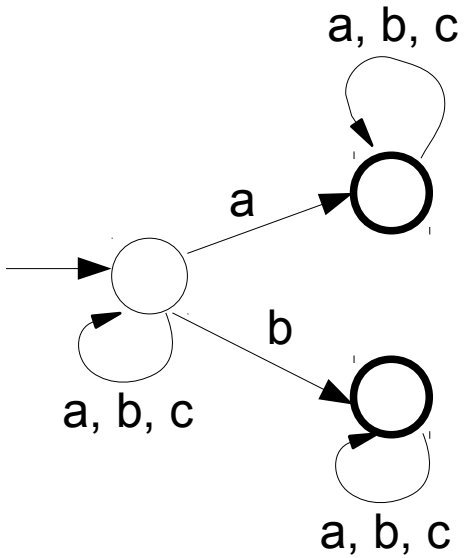
a) show a string accepted by the automaton, and one that is rejected.
Give an equivalent deterministic automaton.

b) Give a regular expression for the strings accepted by the automaton.

c) Is your expression from b) deterministic? Show the Glushkov automaton.

d) give a deterministic regular expression for the strings over {a,b,c} that do not contain the substring “aa” and that end on “a”.

(2) Deterministic Regular Expressions



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a) It accepts “a” and it rejects “c”.

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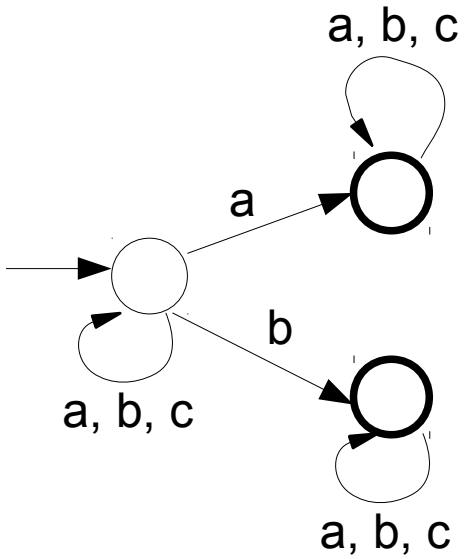

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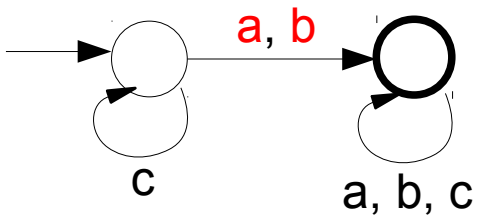
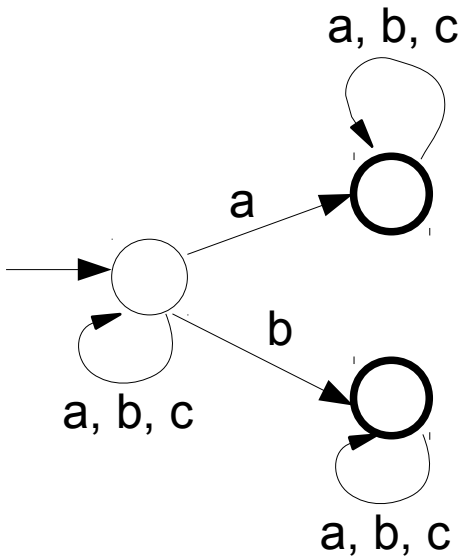


“strings that contain an ‘a’ or a ‘b’”

(2) Deterministic Regular Expressions



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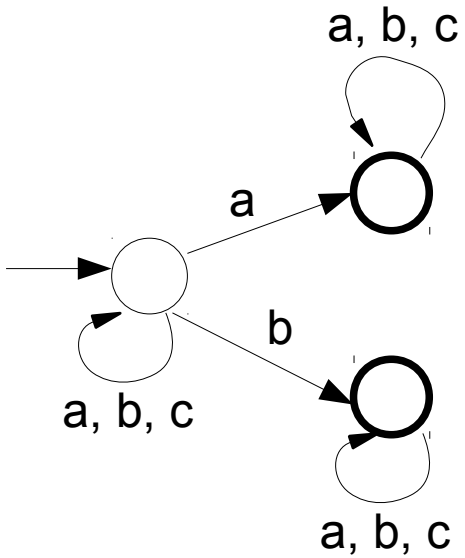

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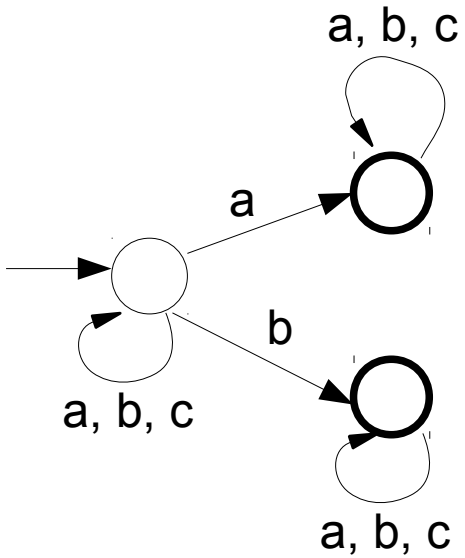
c) Is your expression from b) deterministic?
Show the Glushkov automaton.

d) give a deterministic regular expression for the strings over {a,b,c} that do not contain the substring “aa” and that end on “a”.

b) `c*(a|b)(a|b|c)*`

(2) Deterministic Regular Expressions



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< present on blackboard >

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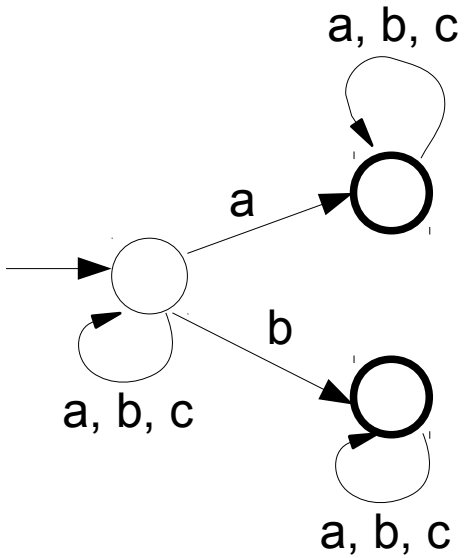

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< present on blackboard / The expression **is** deterministic. >

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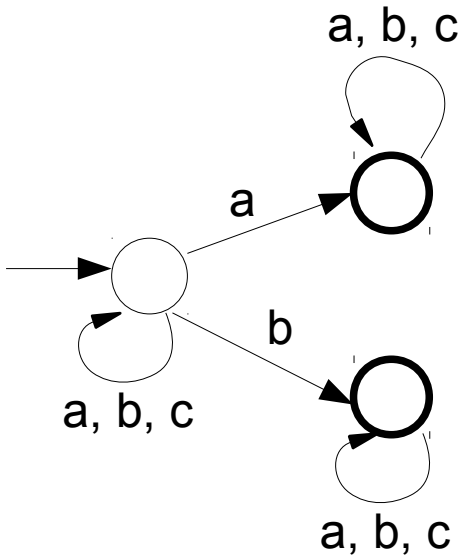

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d)

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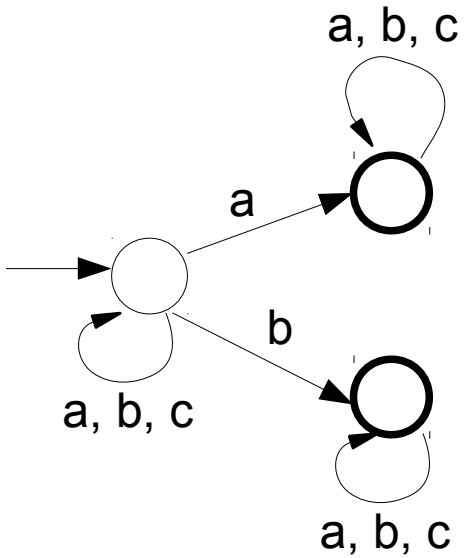

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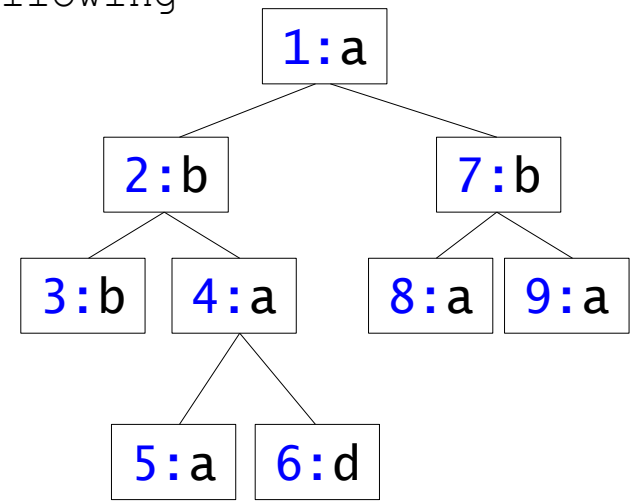
d) give a deterministic regular expression for the strings over {a,b,c} that do not contain the substring “aa” and that end on “a”.

d) `(b|c)*a((b|c)+a)*`

(3) XPath

Write node-numbers of nodes selected by the following XPath expressions:



a) `//a`

b) `/*//*//a[preceding::a]`

c) `//*[.//d]`

d) `/*[not(a and b)]`

e) `//*[count(.//*)= count(ancestor::*)]`

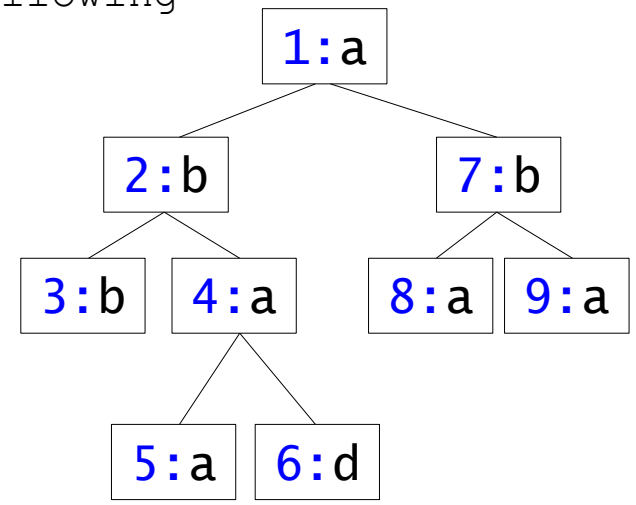
f) `/descendant:*[position() mod 2 = count(.//*)]`

g) `//*[preceding-sibling::b]`

(3) XPath

Write node-numbers of nodes selected by the following XPath expressions:

a) //a

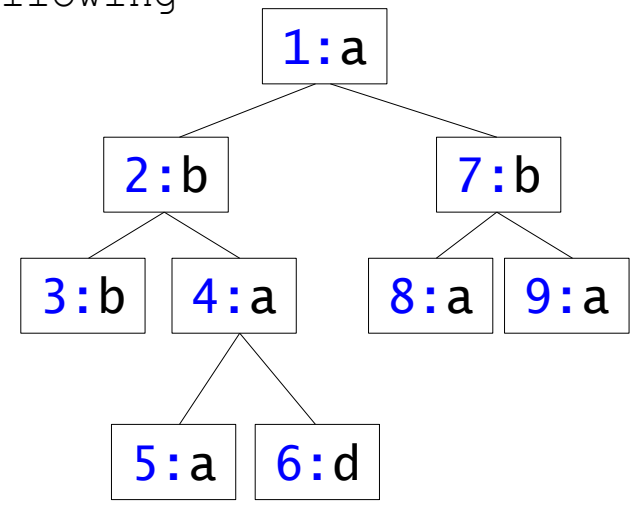


(3) XPath

Write node-numbers of nodes selected by the following XPath expressions:

a) //a

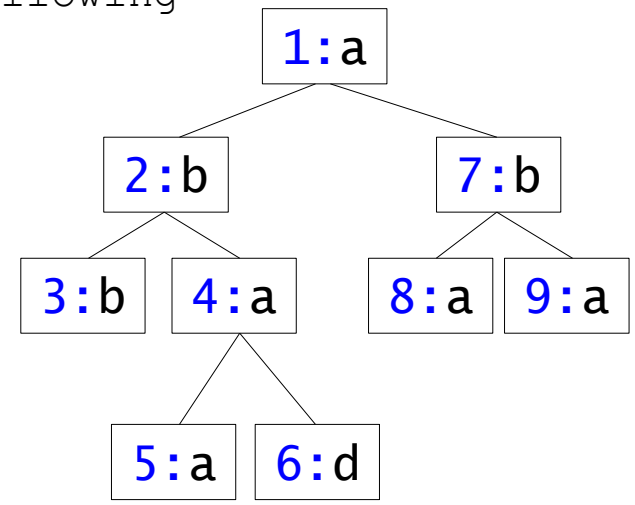
Answer: 1,4,5,8,9



(3) XPath

Write node-numbers of nodes selected by the following XPath expressions:

b) `/*//*//a[preceding::a]`

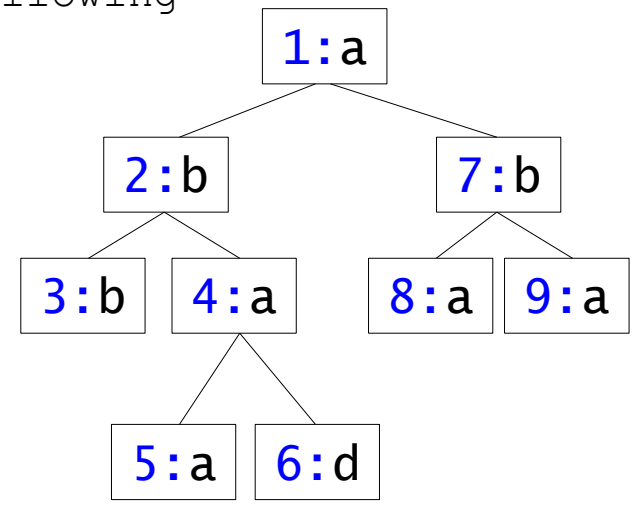


(3) XPath

Write node-numbers of nodes selected by the following XPath expressions:

b) /*//*//a[preceding::a]

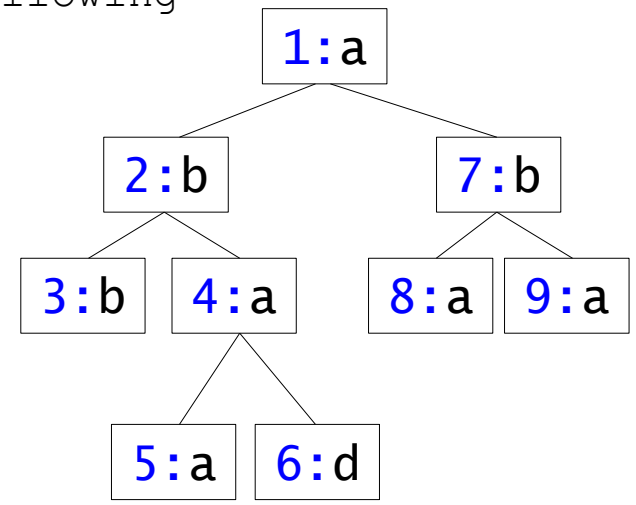
Answer: 8,9



(3) XPath

Write node-numbers of nodes selected by the following XPath expressions:

c) `//*[.//d]`

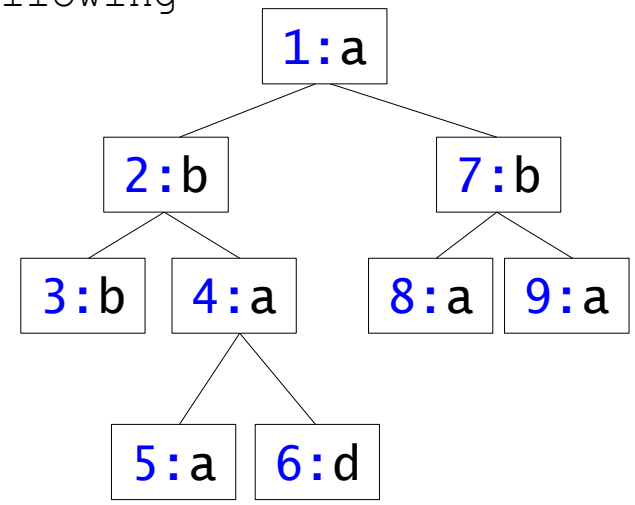


(3) XPath

Write node-numbers of nodes selected by the following XPath expressions:

c) //*[.//d]

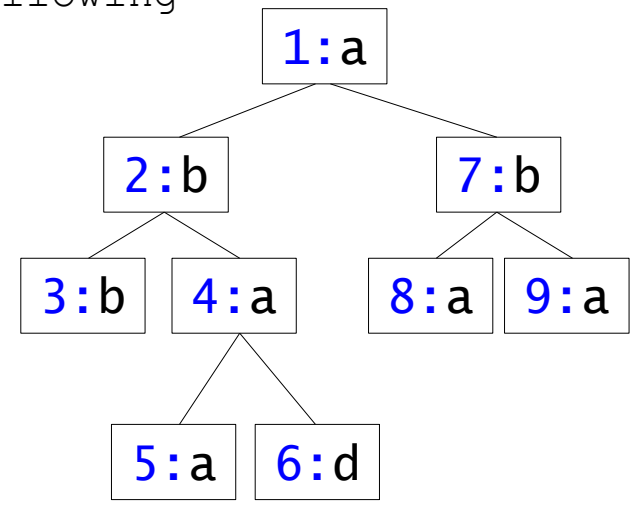
Answer: 1,2,4



(3) XPath

Write node-numbers of nodes selected by the following XPath expressions:

d) /*[not(a and b)]

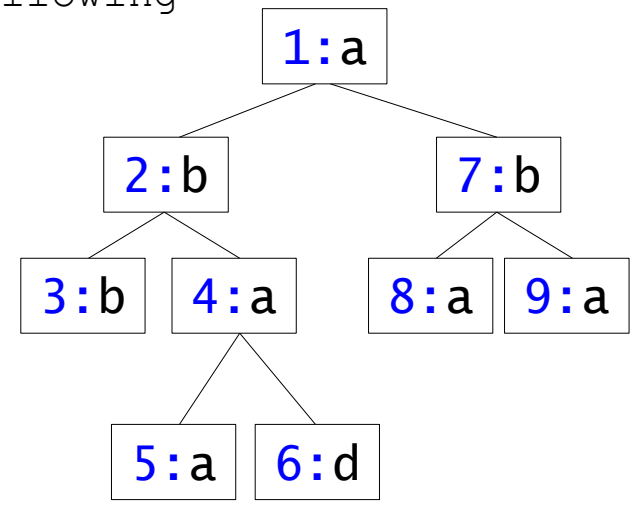


(3) XPath

Write node-numbers of nodes selected by the following XPath expressions:

d) /*[not(a and b)]

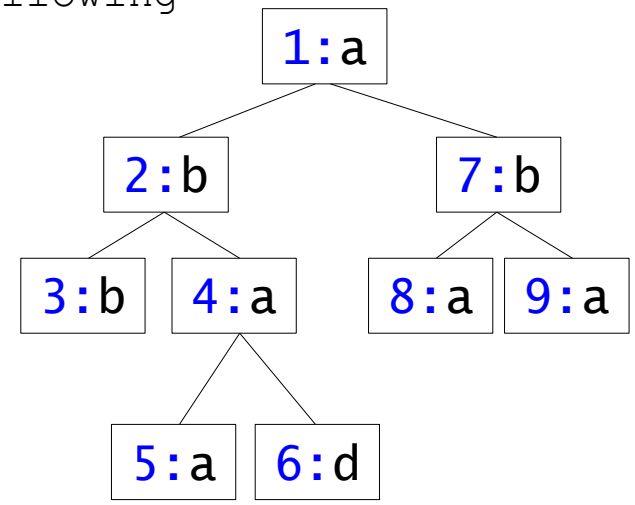
Answer: 1



(3) XPath

Write node-numbers of nodes selected by the following XPath expressions:

e) `//*[count(.//*)= count(ancestor::*)]`

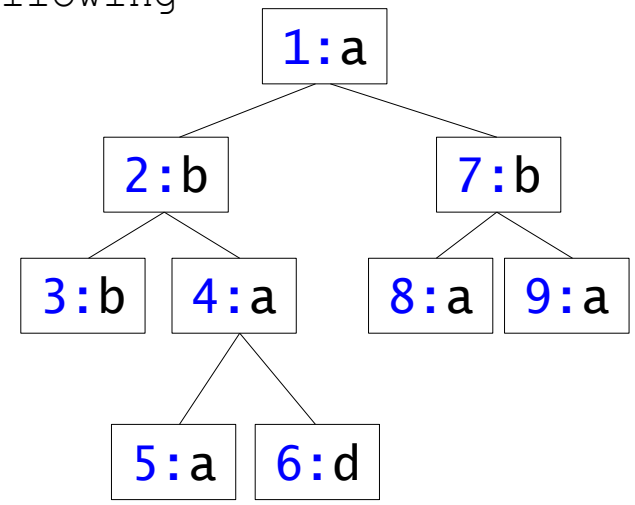


(3) XPath

Write node-numbers of nodes selected by the following XPath expressions:

e) //*[count(.//*)= count(ancestor::*)]

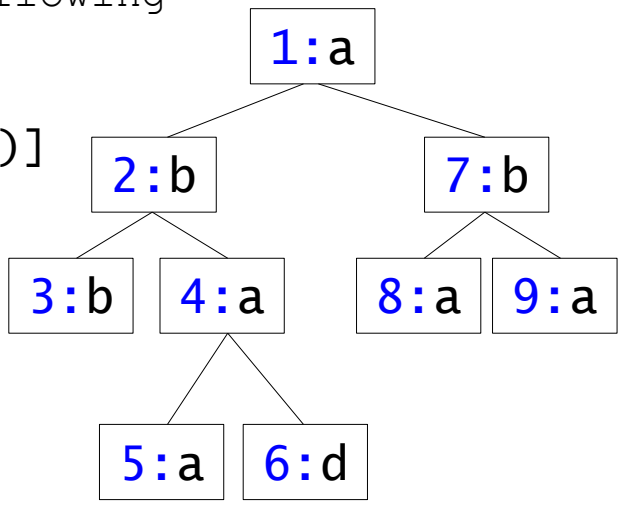
Answer: 4



(3) XPath

Write node-numbers of nodes selected by the following XPath expressions:

f) `/descendant:*[position() mod 2 = count(.//*)]`

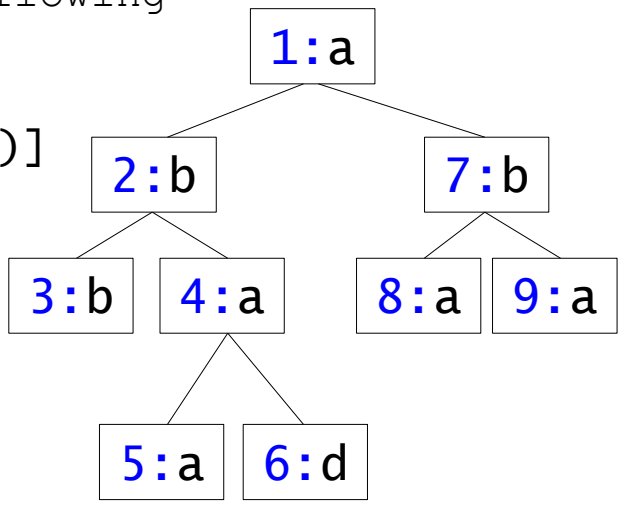


(3) XPath

Write node-numbers of nodes selected by the following XPath expressions:

f) /descendant:*[position() mod 2 = count(.//*)]

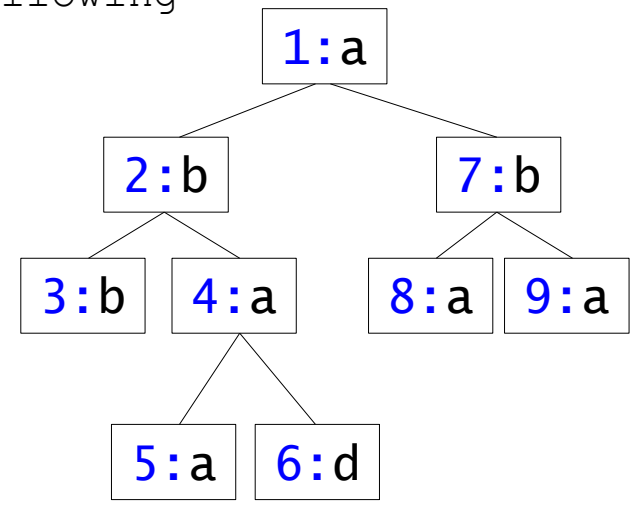
Answer: 6,8



(3) XPath

Write node-numbers of nodes selected by the following XPath expressions:

g) `//*[preceding-sibling::b]`

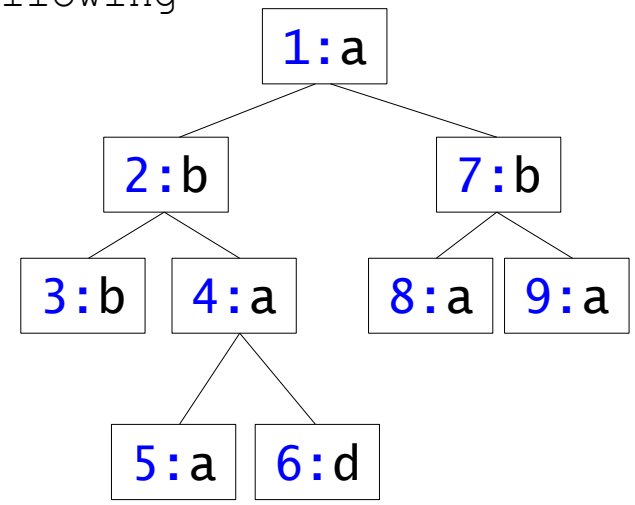


(3) XPath

Write node-numbers of nodes selected by the following XPath expressions:

g) //*[preceding-sibling::b]

Answer: 4, 7



2. Relational DBs

1) explain, using examples, what a functional dependency (fd) is, and what a fd-redundancy is.

2) explain BCNF and how it removes fd-redundancies.

3) are there any “harmful” side-effects when transforming a table to BCNF?

1) explain, using examples, what a functional dependency (fd) is, and what a fd-redundancy is.

Let S and T be non-empty sets of attributes (column names).

A table R has a functional dependency from S to T,
if R's projection to S union T gives a function from S to T.

Such a function implies that for every S-tuple, there is at most one T-tuple in R.

1) explain, using examples, what a functional dependency (fd) is, and what a fd-redundancy is.

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X	A
1	2

Functional dependencies? ("closed world assumption")

1) explain, using examples, what a functional dependency (fd) is, and what a fd-redundancy is.

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Such a function implies that for every S-tuple, there is at most one T-tuple in R.

X	A
1	2

Functional dependencies? ("closed world assumption")

→ how many FDs can there be **at most** for a table with **two columns**?

1) explain, using examples, what a functional dependency (fd) is, and what a fd-redundancy is.

Let S and T be non-empty sets of attributes (column names).

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if R's projection to S union T gives a function from S to T.

Such a function implies that for every S-tuple, there is at most one T-tuple in R.

X	A
1	2

Functional dependencies? ("closed world assumption")

X → X
X → A
X → XA
A → A
A → X
A → XA
XA → X
XA → A
XA → XA

1) explain, using examples, what a functional dependency (fd) is, and what a fd-redundancy is.

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Such a function implies that for every S-tuple, there is at most one T-tuple in R.

X	A
1	2

Functional dependencies? ("closed world assumption")

X → X
X → A
X → XA
A → A
A → X
A → XA

XA → X
XA → A
XA → XA

X → A
A → X

FD's with disjoint S, T

1) explain, using examples, what a functional dependency (fd) is, and what a fd-redundancy is.

Let S and T be non-empty sets of attributes (column names).

A table R has a functional dependency from S to T,
if R's projection to S union T gives a function from S to T.

Such a function implies that for every S-tuple, there is at most one T-tuple in R.

X	A
1	2

Functional dependencies? ("closed world assumption")

→ what are the superkeys?

1) explain, using examples, what a functional dependency (fd) is, and what a fd-redundancy is.

Let S and T be non-empty sets of attributes (column names).

A table R has a functional dependency from S to T,
if R's projection to S union T gives a function from S to T.

Such a function implies that for every S-tuple, there is at most one T-tuple in R.

X	**A**
1	2

Functional dependencies? ("closed world assumption")

→ what are the superkeys?

1) **X**
2) **A**
3) **XA**

1) explain, using examples, what a functional dependency (fd) is, and what a fd-redundancy is.

Let S and T be non-empty sets of attributes (column names).

A table R has a functional dependency from S to T,
if R's projection to S union T gives a function from S to T.

Such a function implies that for every S-tuple, there is at most one T-tuple in R.

X	A
1	2

Functional dependencies? ("closed world assumption")

→ what are the superkeys?

S is superkey if S → T is a FD
and
S union T = all attributes.

1) explain, using examples, what a functional dependency (fd) is, and what a fd-redundancy is.

Let S and T be non-empty sets of attributes (column names).

A table R has a functional dependency from S to T,
if R's projection to S union T gives a function from S to T.

Such a function implies that for every S-tuple, there is at most one T-tuple in R.

X	A
1	2
2	2

Functional dependencies? ("closed world assumption")
→ and now?

1) explain, using examples, what a functional dependency (fd) is, and what a fd-redundancy is.

Let S and T be non-empty sets of attributes (column names).

A table R has a functional dependency from S to T,
if R's projection to S union T gives a function from S to T.

Such a function implies that for every S-tuple, there is at most one T-tuple in R.

X	A
1	2
2	2

Functional dependencies? ("closed world assumption")
→ and now?

X → X
X → A
X → XA
A → A
~~**A → X**~~
~~**A → XA**~~

XA → X
XA → A
XA → XA

1) explain, using examples, what a functional dependency (fd) is, and what a fd-redundancy is.

Let S and T be non-empty sets of attributes (column names).
Functional dependency from S to T:
for every S-tuple, there is at most one T-tuple in R.

X	A	Z
1	2	5
1	2	6
1	2	7

← how many functional dependencies?

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X	A	Z
1	2	5
1	2	6
1	2	7

← how many functional dependencies?

How many **at most**?
→ (2^3 – 1) * (2^3 – 1) = 7*7 = 49

Which ones are excluded?

A → X, A → Z, A → XZ, A → XAZ
X → A, X → Z, X → AZ, X → XAZ
XA → Z, XA → XAZ

1) explain, using examples, what a functional dependency (fd) is, and what a fd-redundancy is.

Let S and T be non-empty sets of attributes (column names).
Functional dependency from S to T:
for every S-tuple, there is at most one T-tuple in R.

X	A	Z
1	2	5
1	2	6
1	2	7

← how many functional dependencies?

→ how many superkeys?

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Functional dependency from S to T:
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X	A	Z
1	2	5
1	2	6
1	2	7

← how many functional dependencies?

→ how many superkeys?

four

Z, AZ, XZ, XAZ

1) explain, using examples, what a functional dependency (fd) is, and what a fd-redundancy is.

Let S and T be non-empty sets of attributes (column names).
Functional dependency from S to T:
for every S-tuple, there is at most one T-tuple in R.

A table R has fd-redundancy w.r.t. $S \rightarrow T$,
if R contains two distinct tuples with equal (S,T)-values.

1) explain, using examples, what a functional dependency (fd) is, and what a fd-redundancy is.

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Functional dependency from S to T:
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A table R has fd-redundancy w.r.t. S → T ,
if R contains two distinct tuples with equal (S,T)-values.

X	A	Z
1	2	5
1	2	6

← are there any fd-redundancies?

1) explain, using examples, what a functional dependency (fd) is, and what a fd-redundancy is.

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Functional dependency from S to T:
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A table R has fd-redundancy w.r.t. S → T ,
if R contains two distinct tuples with equal (S,T)-values.

X	A	Z
1	2	5
1	2	6

← are there any fd-redundancies?

Yes: 1) fd-redundancy wrt **X** → **A**
2) fd-redundancy wrt **A** → **X**

1) explain, using examples, what a functional dependency (fd) is, and what a fd-redundancy is.

Let S and T be non-empty sets of attributes (column names).
Functional dependency from S to T:
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A table R has fd-redundancy w.r.t. S → T ,
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X	A	Z
1	2	5
1	2	6
2	2	6

← list all fd-redundancies!

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X	A	Z
1	2	5
1	2	6
2	2	6

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1) fd-redundancy wrt **X** → **A**

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X	A	Z
1	2	5
1	2	6
2	2	6

← list all fd-redundancies!

1) fd-redundancy wrt **X** → **A**

→ **A** to **X** is not a functional depencency anymore!

1) explain, using examples, what a functional dependency (fd) is, and what a fd-redundancy is.

Let S and T be non-empty sets of attributes (column names).
Functional dependency from S to T:
for every S-tuple, there is at most one T-tuple in R.

A table R has fd-redundancy w.r.t. S → T ,
if R contains two distinct tuples with equal (S,T)-values.

X	A	Z
1	2	5
1	2	6
2	2	6

← list all fd-redundancies!

1) fd-redundancy wrt **X** → **A**
→ **A** to **X** is not a functional depencency anymore!

2) fd-redundancy wrt **Z** → **A**

2) explain BCNF and how it removes fd-redundancies.

BCNF = if $S \rightarrow T$ is a functional dependency of R, then S is a superkey.

(assuming S disjoint T)

2) explain BCNF and how it removes fd-redundancies.

BCNF = if $S \rightarrow T$ is a functional dependency of R, then S is a superkey.

(assuming S disjoint T)

X	A
1	2
2	2

← in BCNF?

2) explain BCNF and how it removes fd-redundancies.

BCNF = if $S \rightarrow T$ is a functional dependency of R, then S is a superkey.

(assuming S disjoint T)

X	A
1	2
2	2

← in BCNF?

Yes: **X** is superkey, and
X → **A** is the only functional dependency.

2) explain BCNF and how it removes fd-redundancies.

BCNF = if S → T is a functional dependency of R, then S is a superkey.

(assuming S disjoint T)

X	A	Z
1	2	5
1	2	6

← in BCNF?

2) explain BCNF and how it removes fd-redundancies.

BCNF = if S → T is a functional dependency of R, then S is a superkey.

(assuming S disjoint T)

X	A	Z
1	2	5
1	2	6

← in BCNF?

No: **X** → **A** is fd, but **X** is not a superkey

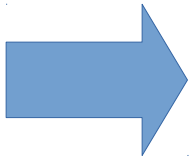
A → **X** is fd, but **A** is not a superkey

2) explain BCNF and how it removes fd-redundancies.

BCNF = if S → T is a functional dependency of R, then S is a superkey.

(assuming S disjoint T)

X	A	Z
1	2	5
1	2	6



X	A
1	2
1	2

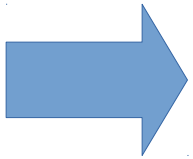
X	Z
1	5
1	6

2) explain BCNF and how it removes fd-redundancies.

BCNF = if $S \rightarrow T$ is a functional dependency of R, then S is a superkey.

(assuming S disjoint T)

X	A	Z
1	2	5
1	2	6



X	A
1	2
1	2

X	Z
1	5
1	6

In BCNF, there can be **no** fd-redundancies.

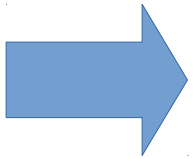
Why?

2) explain BCNF and how it removes fd-redundancies.

BCNF = if $S \rightarrow T$ is a functional dependency of R, then S is a superkey.

(assuming S disjoint T)

X	A	Z
1	2	5
1	2	6



X	A
1	2
1	2

X	Z
1	5
1	6

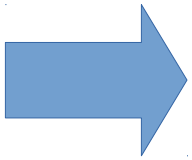
In BCNF, there can be **no** fd-redundancies.

Why?

Would imply that a tuple exists twice in R with same superkey-values

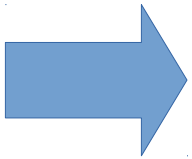
3) are there any “harmful” side-effects when transforming a table to BCNF?

X	A	Z
1	2	5
1	2	6
2	2	6



3) are there any “harmful” side-effects when transforming a table to BCNF?

X	A	Z
1	2	5
1	2	6
2	2	6

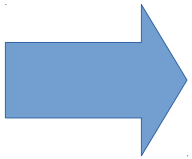


X	A
1	2
2	2

X	Z
1	5
1	6
2	6

3) are there any “harmful” side-effects when transforming a table to BCNF?

X	A	Z
1	2	5
1	2	6
2	2	6



X	A
1	2
2	2

X	Z
1	5
1	6
2	6

We lost the dependency **XZ** → **A**

END
Lecture 19