

Tutorial 2

Week of Sept. 21-25th, 2009

For each of the following languages, a) provide a context-free grammar in BNF that generates all strings in the language and no other strings or say it cannot be done, and b) provide a regular expression that accepts all strings in the language or say it cannot be done. No proof is required. If you claim that a context-free grammar / regular expression cannot be provided, you do not have to explain why.

- a. (4 marks) Non-increasing comma-separated sequences of digits between 0 and 5, that end with 0.
- b. (4 marks) Strings over $\{a, b\}$ with more a 's than b 's.
- c. (4 marks) Java method headers (a highly simplified version). That is, strings of the form:
`<mod> static <return> <name> (<arguments>)`
where `<mod>` is either `public` or `private`,
`static` is optional,
`<return>` is either `void`, or `int`, or `double`,
`<name>` is any alphanumeric string that does not begin with a digit, and
`<arguments>` is a non-empty comma-separated list of pairs `<type> <arg>`,
where `<type>` is either `int` or `double`
and `<arg>` is an alphanumeric string that does not begin with a digit.
- d. (4 marks) Binary strings that do not contain 000 as a sub-string.
- e. (4 marks) Strings over the alphabet $\{a, b, \{, \}, (,)\}$ such that braces and parentheses are properly balanced.

Question 1. (20 marks)

a. (4 marks) RE: $(5,)^*(4,)^*(3,)^*(2,)^*(1,)^*(0,)^*0$

CFG: $\Sigma = \{0, 1, 2, 3, 4, 5\}$, $V = \{\langle zero \rangle, \langle one \rangle, \langle two \rangle, \langle three \rangle, \langle four \rangle, \langle five \rangle, \langle s \rangle\}$, $S = \langle s \rangle$, P :

```
<s> ::= <five><four><three><two><one><zero>0
<five> ::= epsilon | 5,<five>
<four> ::= epsilon | 4,<four>
<three> ::= epsilon | 3,<three>
<two> ::= epsilon | 2,<two>
<one> ::= epsilon | 1,<one>
<zero> ::= epsilon | 0,<zero>
```

b. (4 marks) RE: CBD

CFG: $\Sigma = \{a, b\}$, $V = \{\langle s \rangle, \langle ab \rangle\}$, $S = \langle s \rangle$, P :

```
<s> ::= a | <s> a <s> b <s> | <s> b <s> a <s> | <s> a <s>
```

c. (4 marks) Let 's' stand for $(A+B+\dots+Z+a+b+\dots+z)(A+B+\dots+Z+a+b+\dots+z+0+1+\dots+9)^*$.

RE: $(public + private)(static + \epsilon)(void + int + double)'s$ ““(‘s,)*‘s “”

CFG: $\Sigma = \{A, \dots, Z, a, \dots, z, 0, \dots, 9, (,)\}$, $V = \{\langle s \rangle, \langle mod \rangle, \langle static \rangle, \langle return \rangle, \langle args \rangle, \langle type \rangle, \langle st \rangle, \langle char \rangle\}$, $S = \langle s \rangle$, P :

```
<s> ::= <mod> <static> <return> <stn> ( <args> )
<mod> ::= public | private
<static> ::= static | epsilon
<return> ::= <type> | void
<args> ::= <type> <stn> | <type> <stn> , <args>
<type> ::= int | double
<stn> ::= <letter><st>
<st> ::= <char> | <char> <st>
<char> ::= <letter>|0|1|...|9
<letter> ::= A|B|...|Z|a|b|...|z
```

d. (4 marks) RE: $(1 + 01 + 001)^*$

CFG: $\Sigma = \{0, 1\}$, $V = \{\langle s \rangle\}$, $S = \langle s \rangle$, P :

```
<s> ::= 1<s> | 01<s> | 001<s>
```

e. (4 marks) RE: CBD

CFG: $\Sigma = \{a, b, \{, \}, (,)\}$, $V = \{\langle s \rangle, \langle ab \rangle\}$, $S = \langle s \rangle$, P :

```
<s> ::= <s> ( <s> ) <s> | <s> { <s> } <s> | <ab>
<ab> ::= epsilon | a<ab> | b<ab>
```