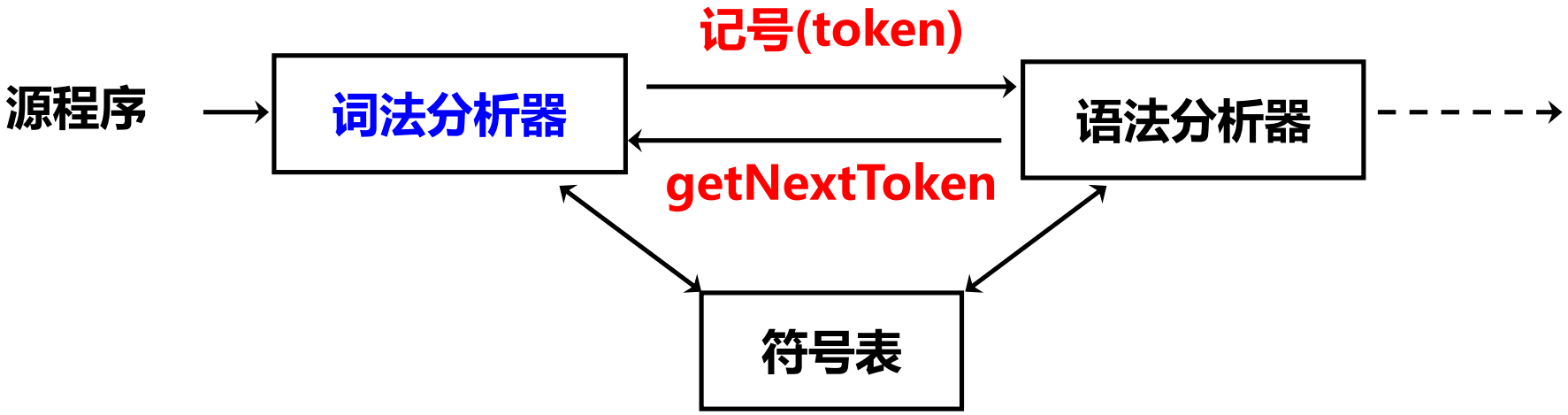
中国科学技术大学
University of Science and Technology of China
USTC, CHINA
ADSLAB
先进数据系统实验室

《编译原理与技术》
词法分析 II

计算机科学与技术学院
李 诚
13/09/2018

主要内容

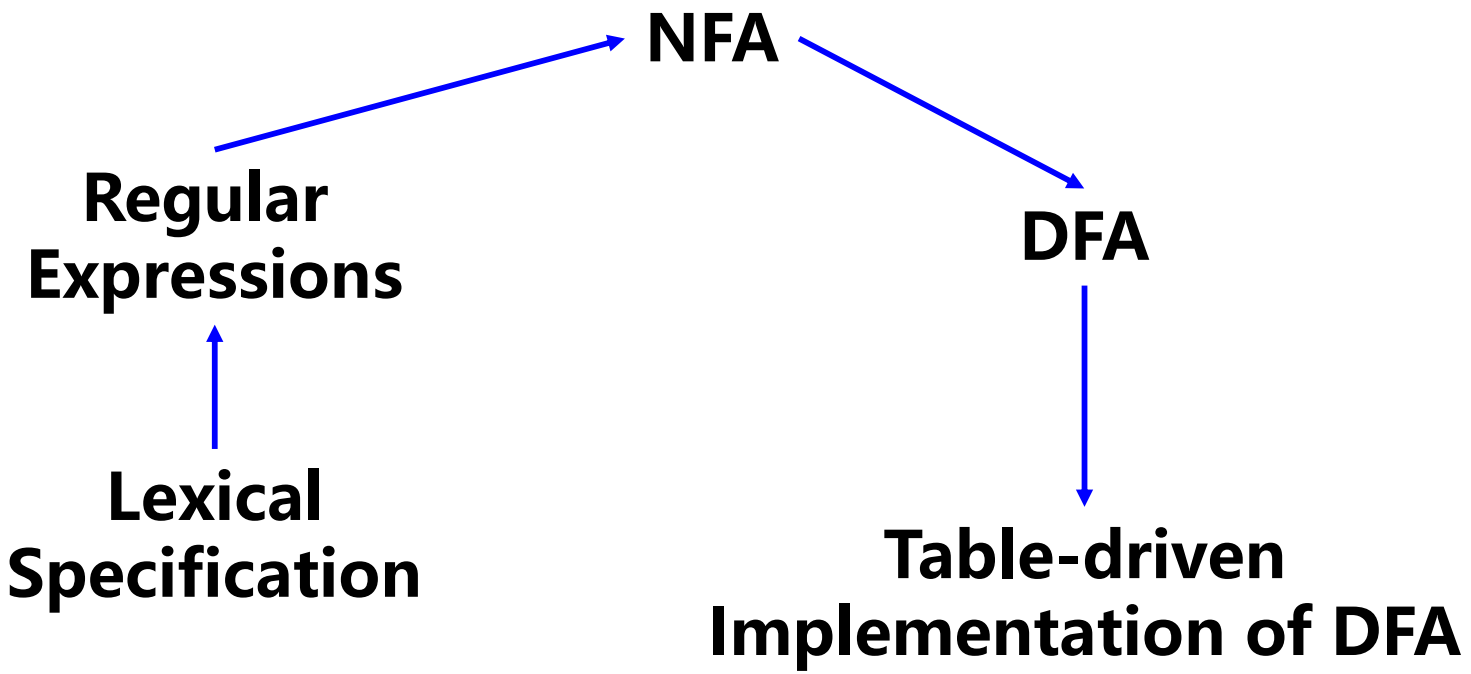


- 词法分析器的自动生成
  - 正则表达式→NFA → DFA →化简的DFA
- 词法分析器的生成器
  - Lex: flex、jflex

Fast lexical analyzer generator

Regular Expr to NFA

- 正则表达式 = Specification
- 有限自动机 = Implementation

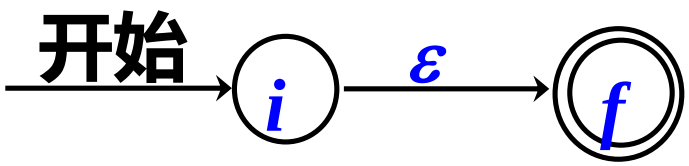


Regular Expr to NFA

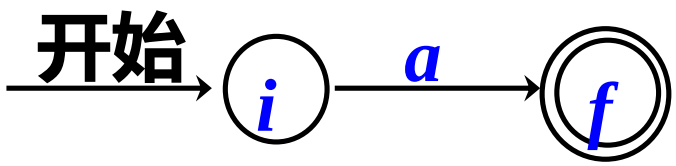
- 正则表达式 = Specification
- 有限自动机 = Implementation

- 二者之间的转换：
  - 用语法制导的算法，它用正则表达式的语法结构来指导有限自动机的构造过程

- 首先构造识别ε和字母表中一个符号a的NFA
  - 重要特点：仅一个接受状态，它没有向外的转换



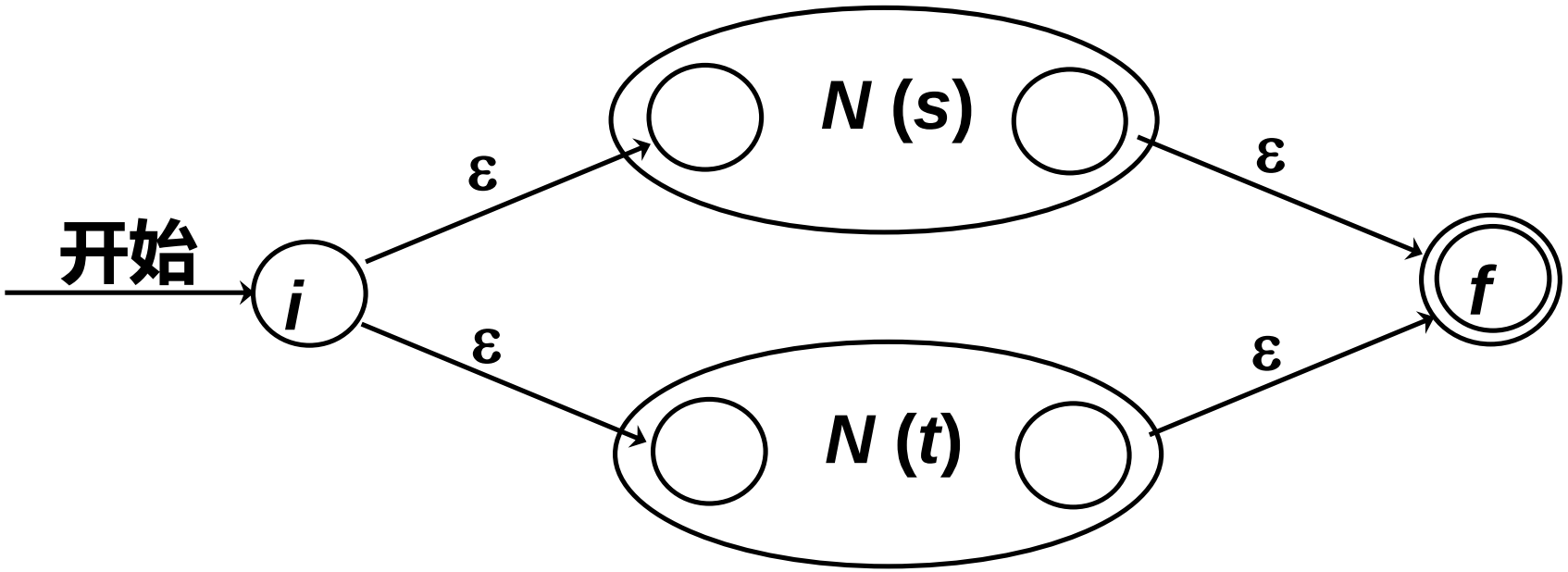
识别正则表达式ε的NFA



识别正则表达式a的NFA

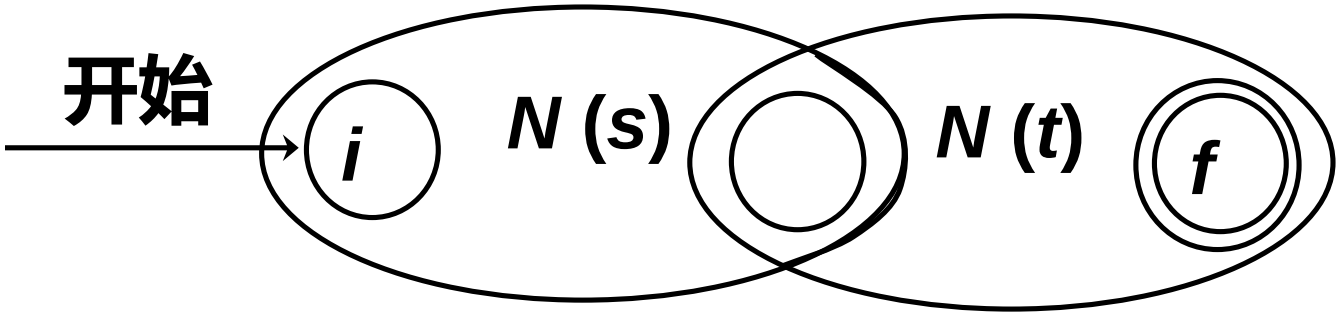
- 对于加括号的正则表达式(s)，其NFA可用s的NFA（用N(s)表示）代替

- 构造识别主算符为选择的正则表达式的NFA
  - 重要特点：仅一个接受状态，它没有向外的转换



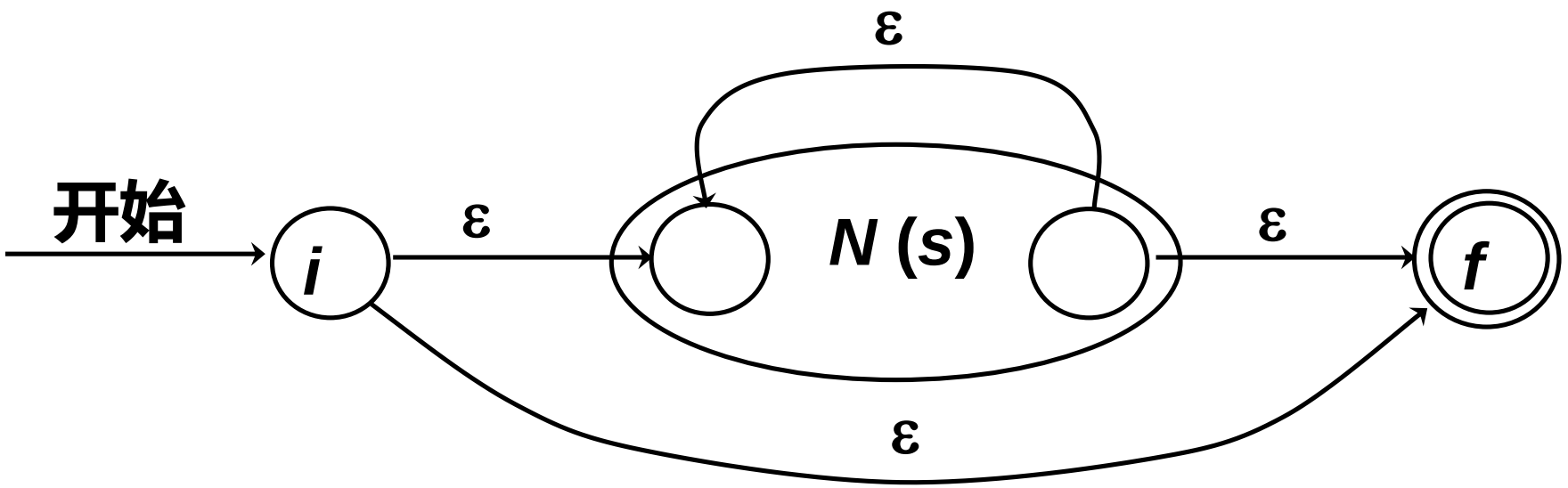
识别正则表达式 $s \mid t$ 的NFA

- 构造识别主算符为连接的正则表达式的NFA
  - 重要特点：仅一个接受状态，它没有向外的转换



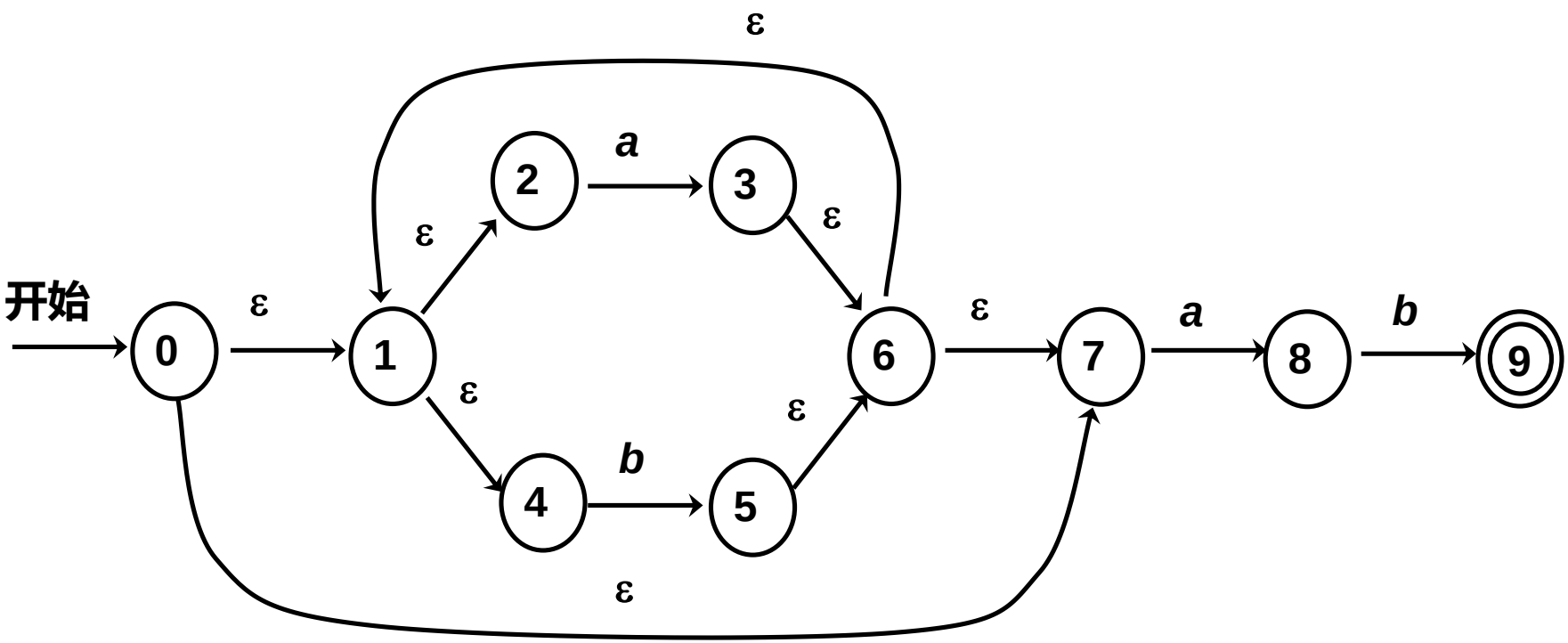
识别正则表达式*st* 的NFA

- 构造识别主算符为闭包的正则表达式的NFA
  - 重要特点：仅一个接受状态，它没有向外的转换

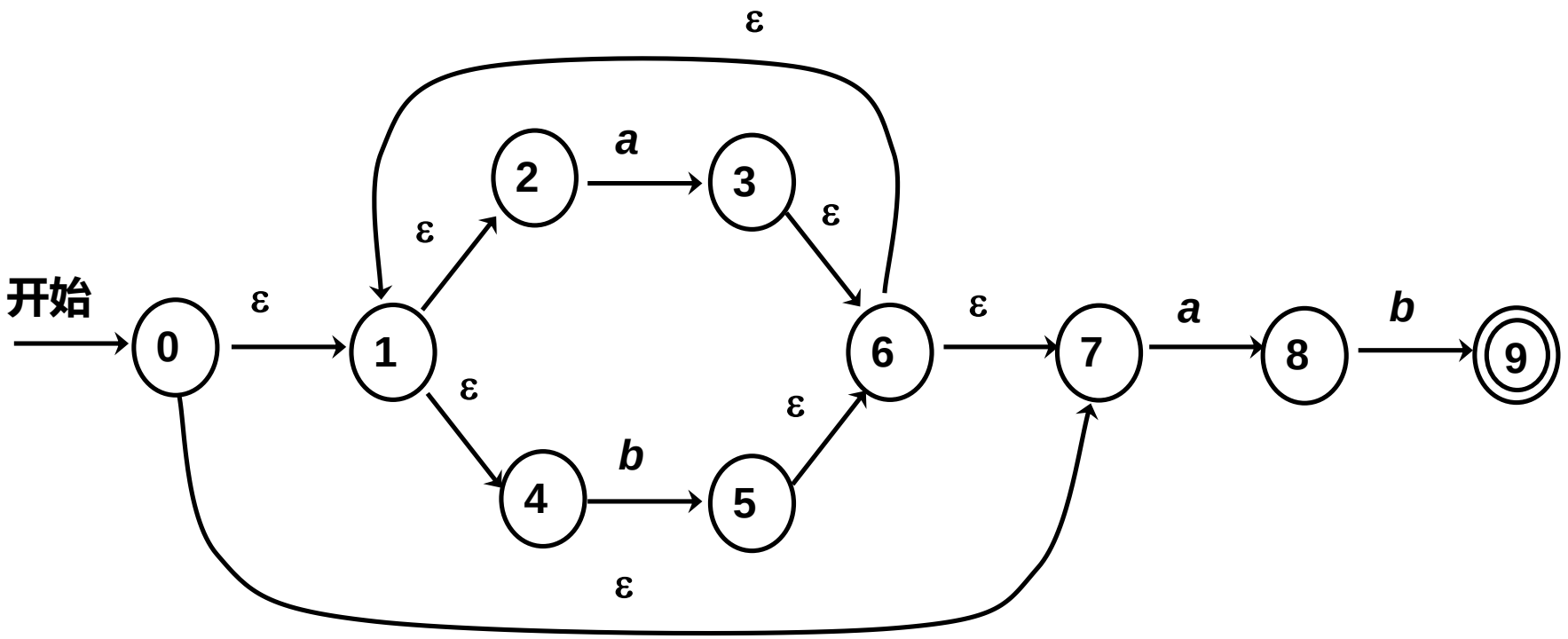


识别正则表达式s^*的NFA

- 由本方法产生的NFA具有下列性质：
  - N(r)的状态数最多是r中符号和算符总数的两倍
  - N(r)只有一个接受状态，接受状态没有向外的转换

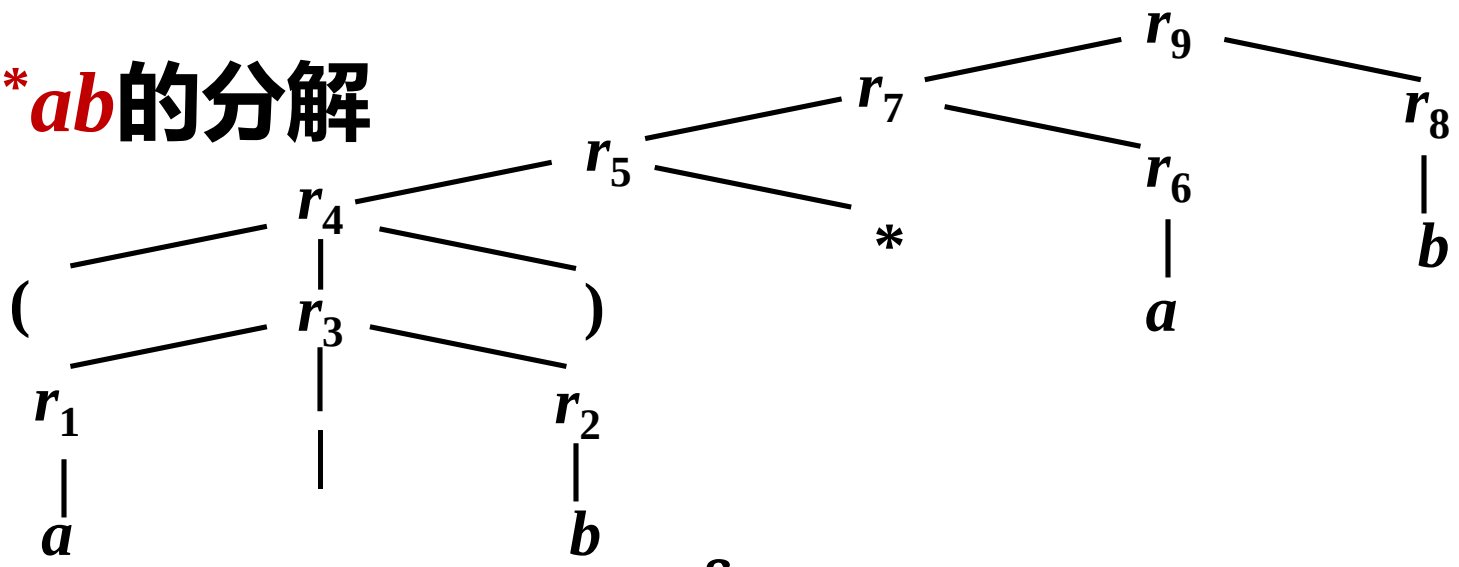


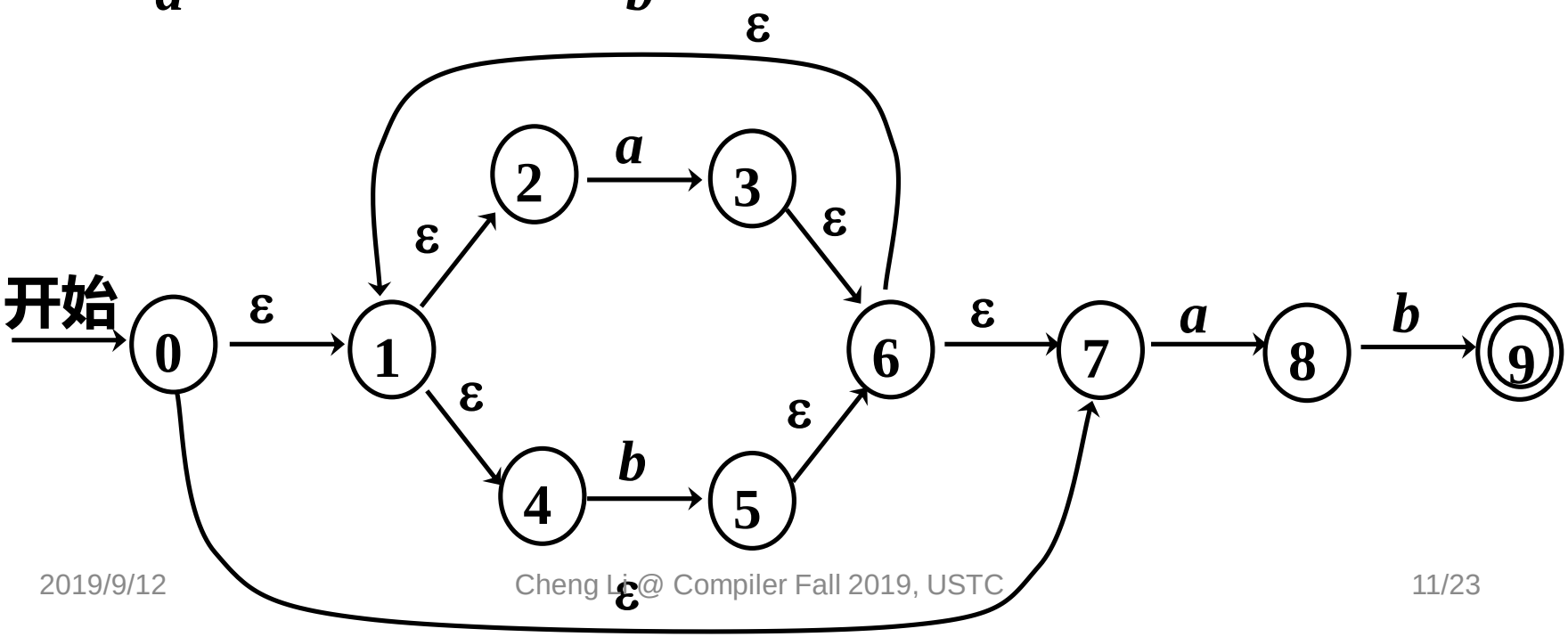
- 由本方法产生的NFA具有下列性质：
  - N(r)的每个状态有(1)一个其标号为∑中符号的指向其它状态的转换，或者(2)最多两个指向其它状态的ε转换



NFA构造过程举例

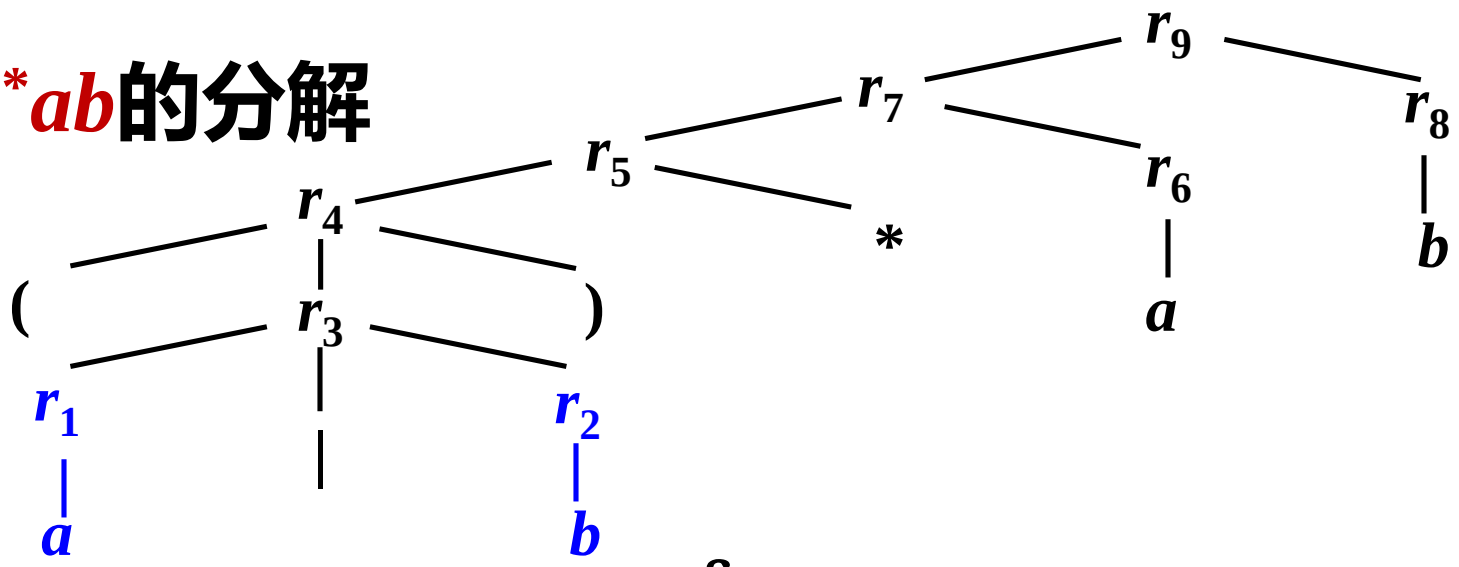
$(a|b)^*ab$的分解

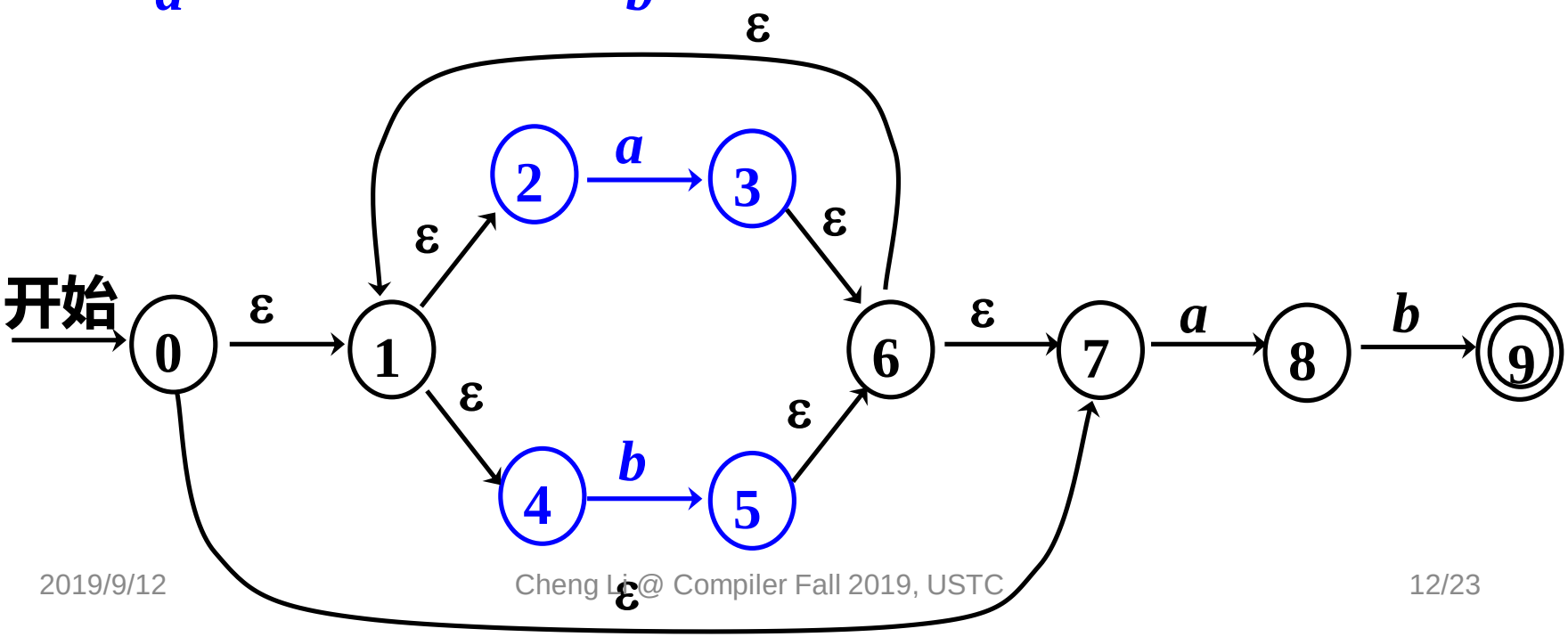




NFA构造过程举例

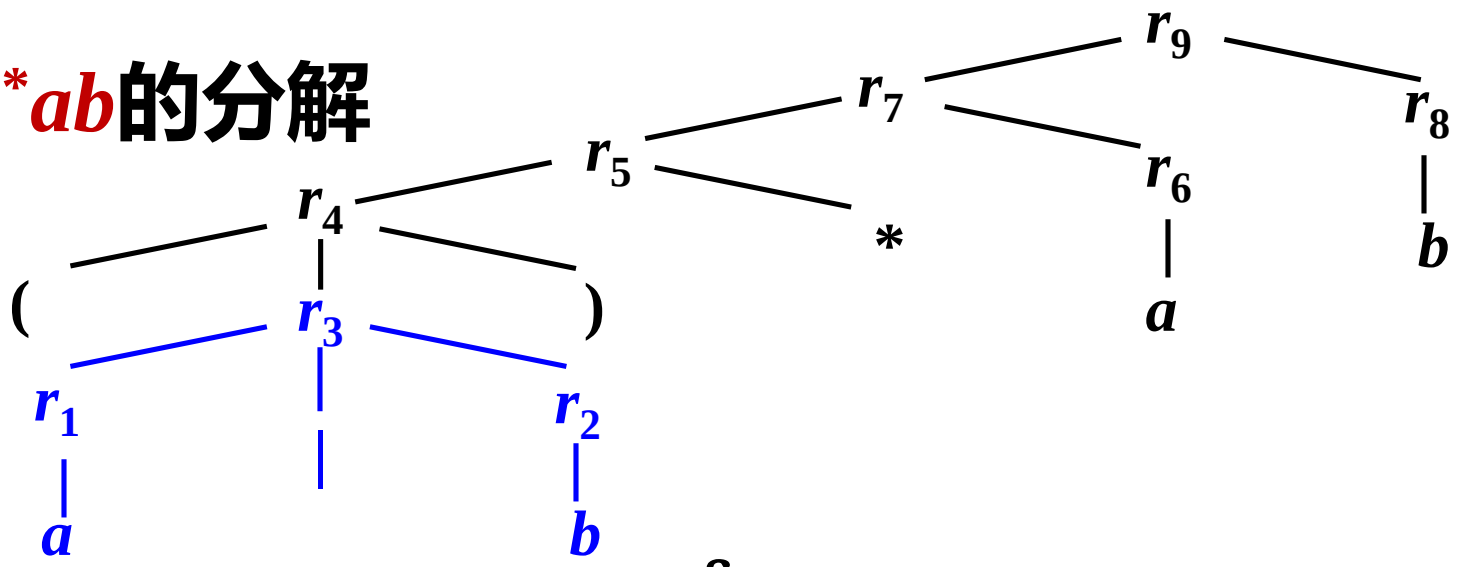
$(a|b)^*ab$的分解

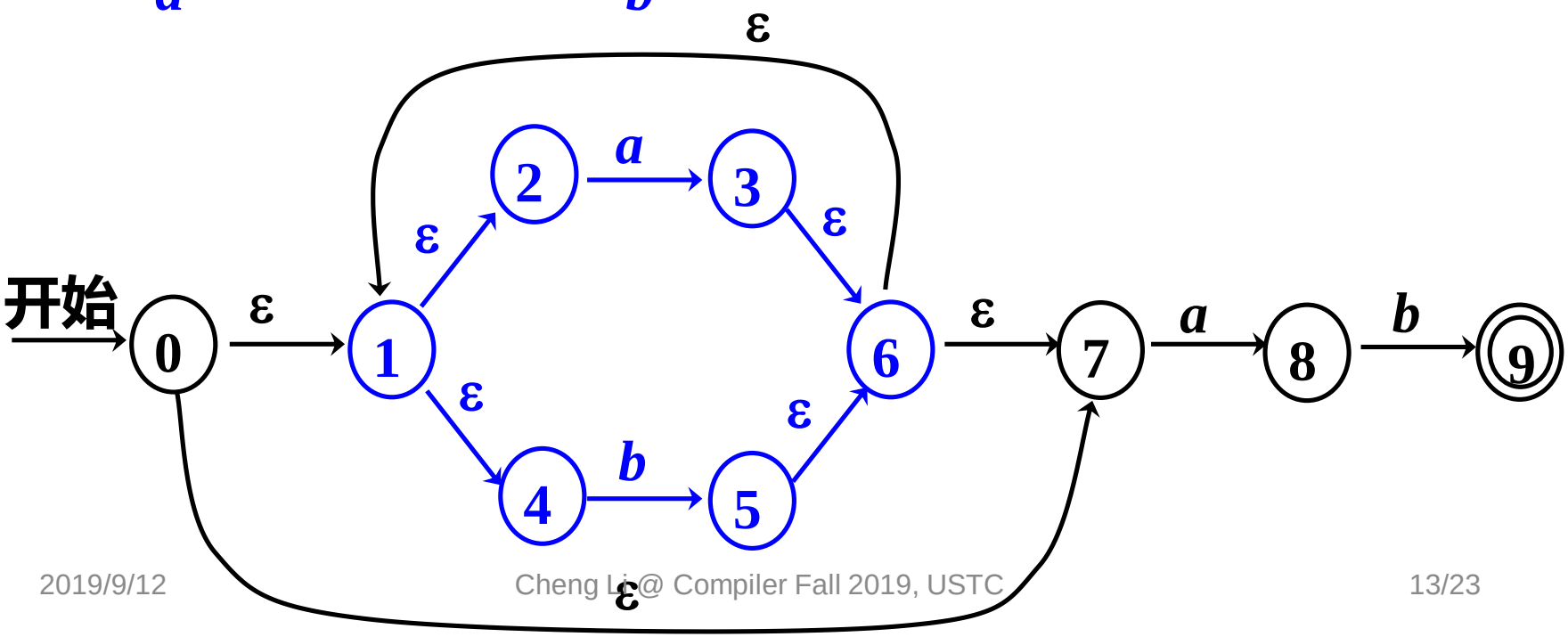




NFA构造过程举例

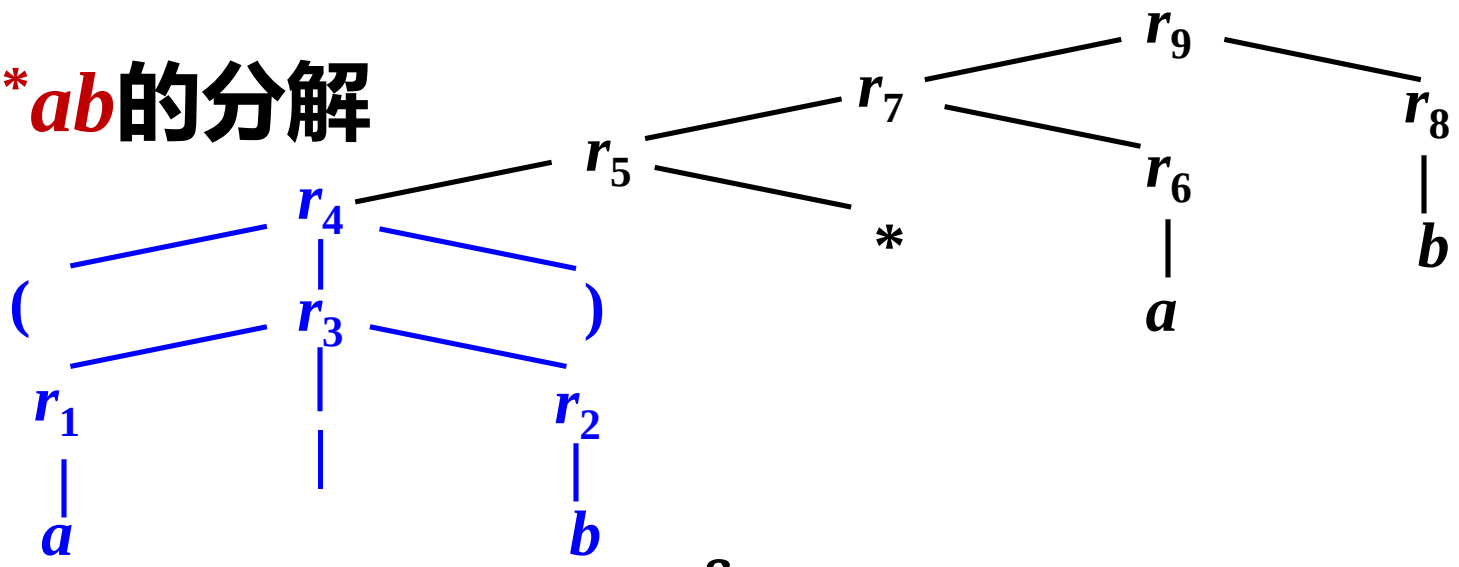
$(a|b)^*ab$的分解

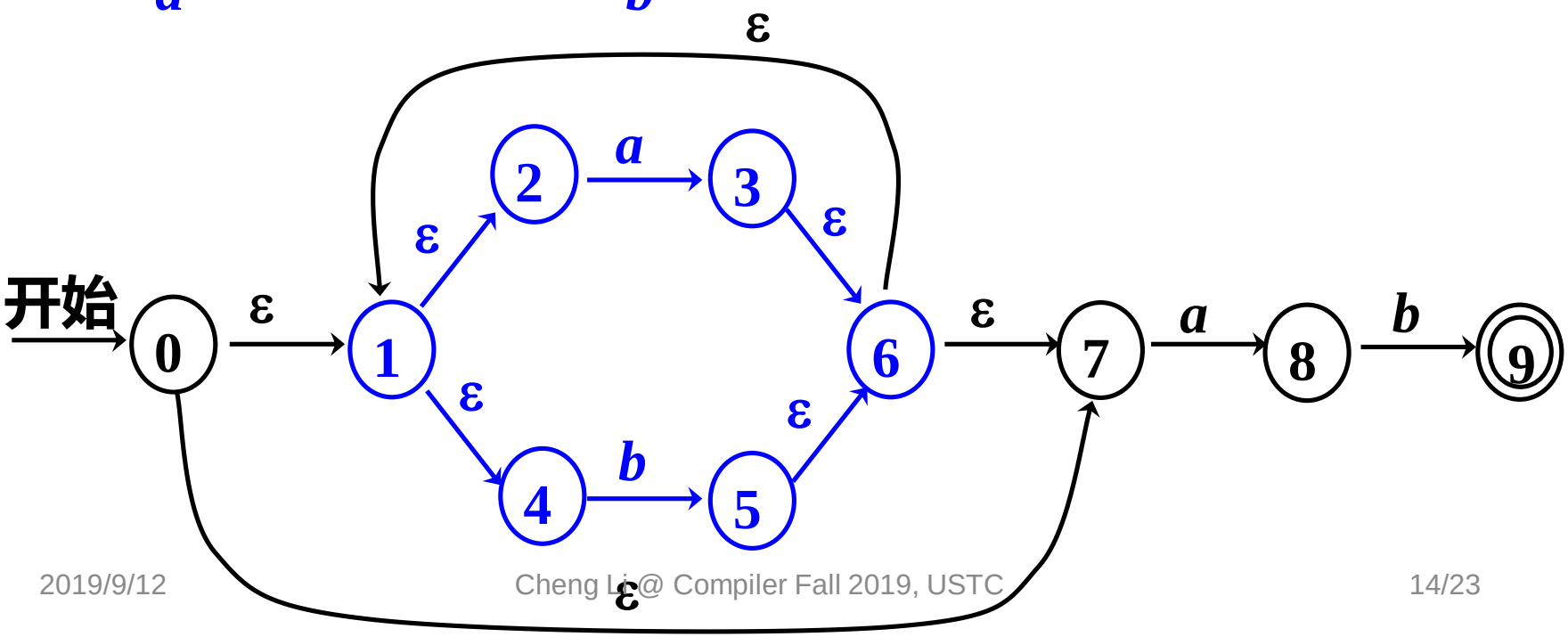




NFA构造过程举例

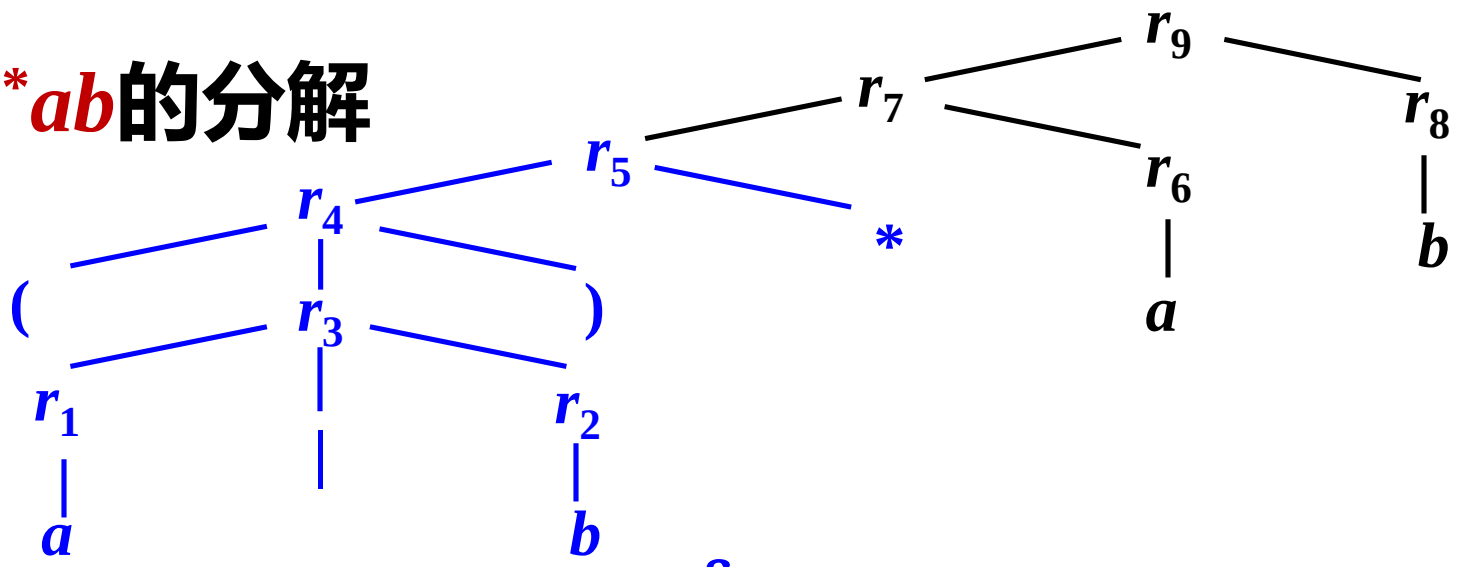
$(a|b)^*ab$的分解

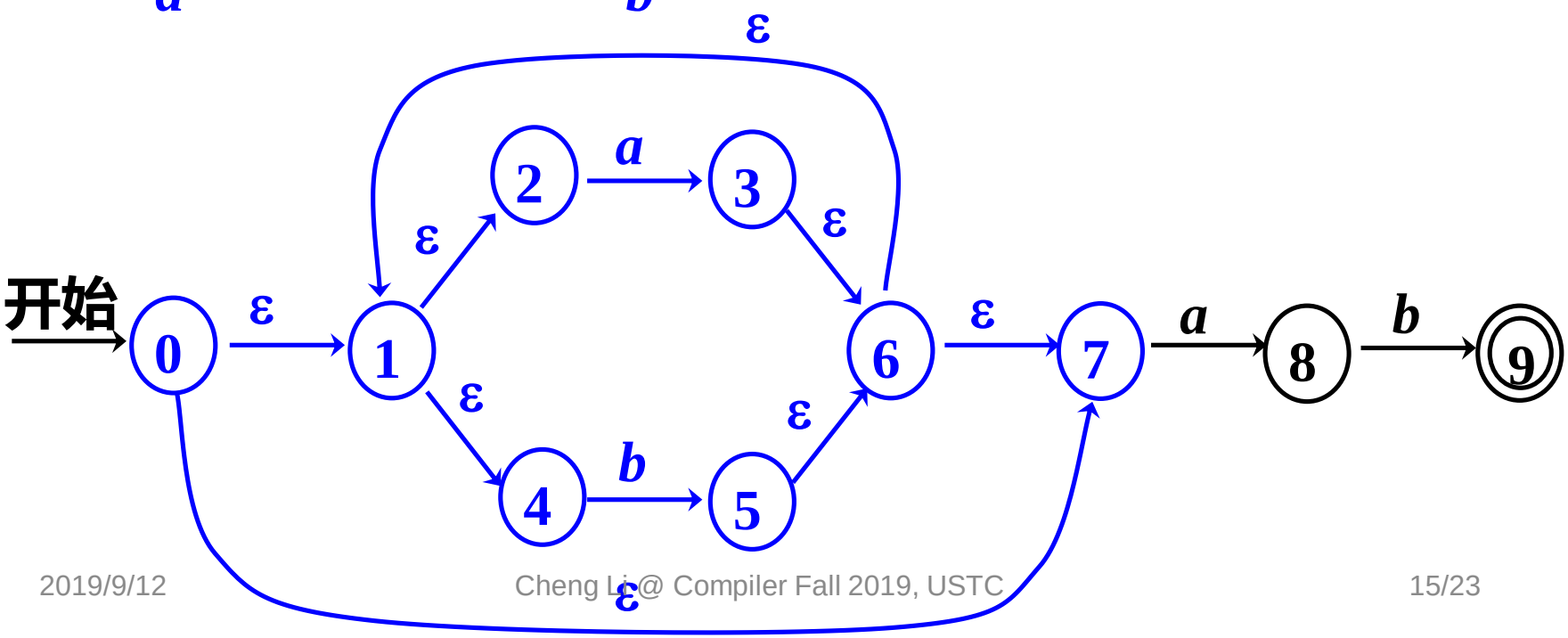




NFA构造过程举例

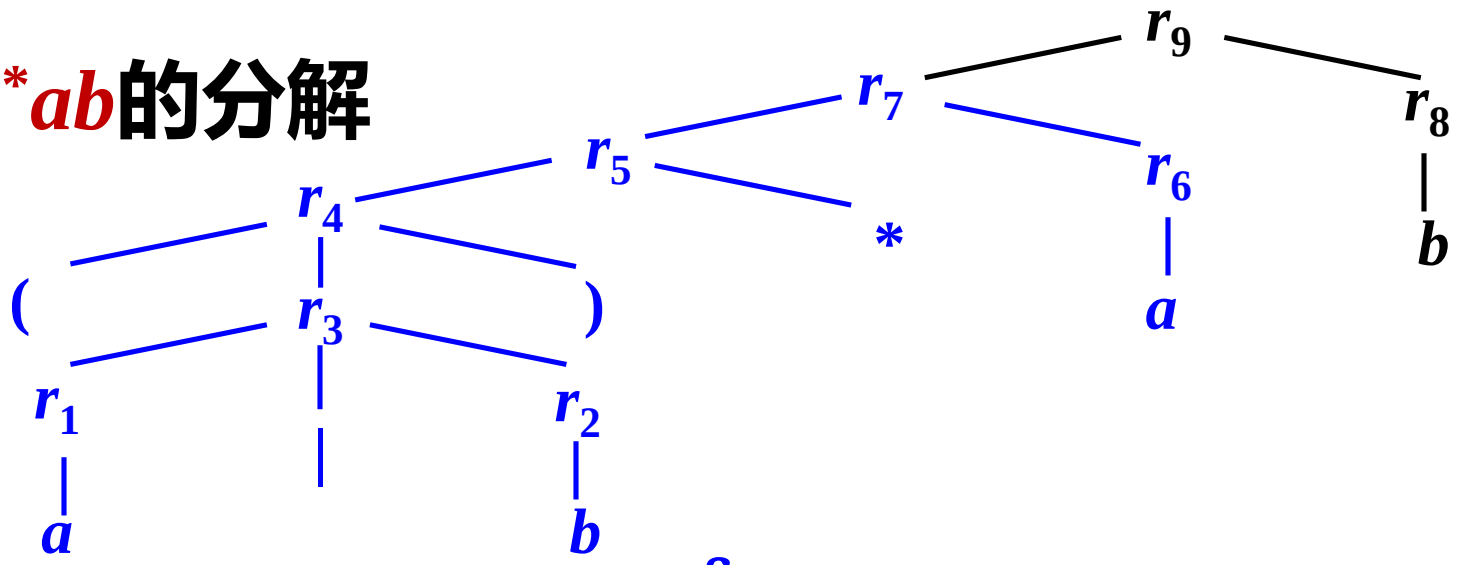
$(a|b)^*ab$的分解

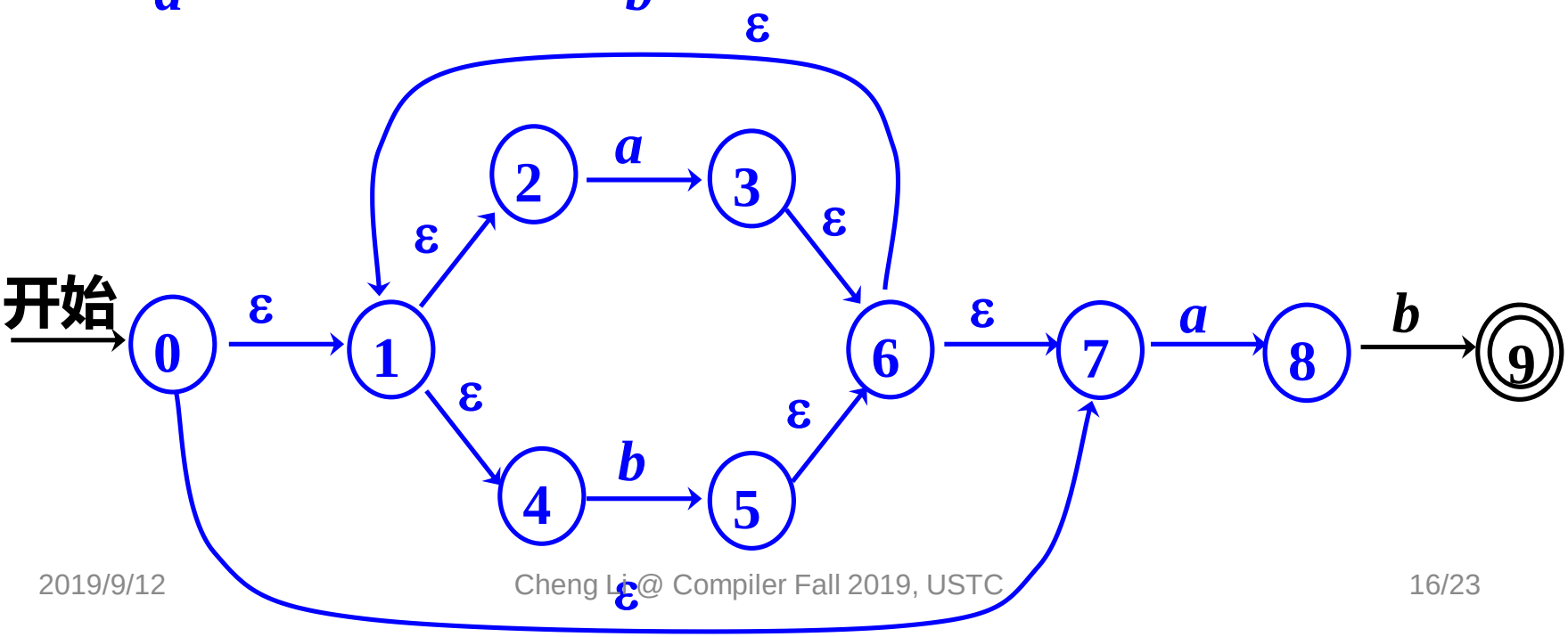




NFA构造过程举例

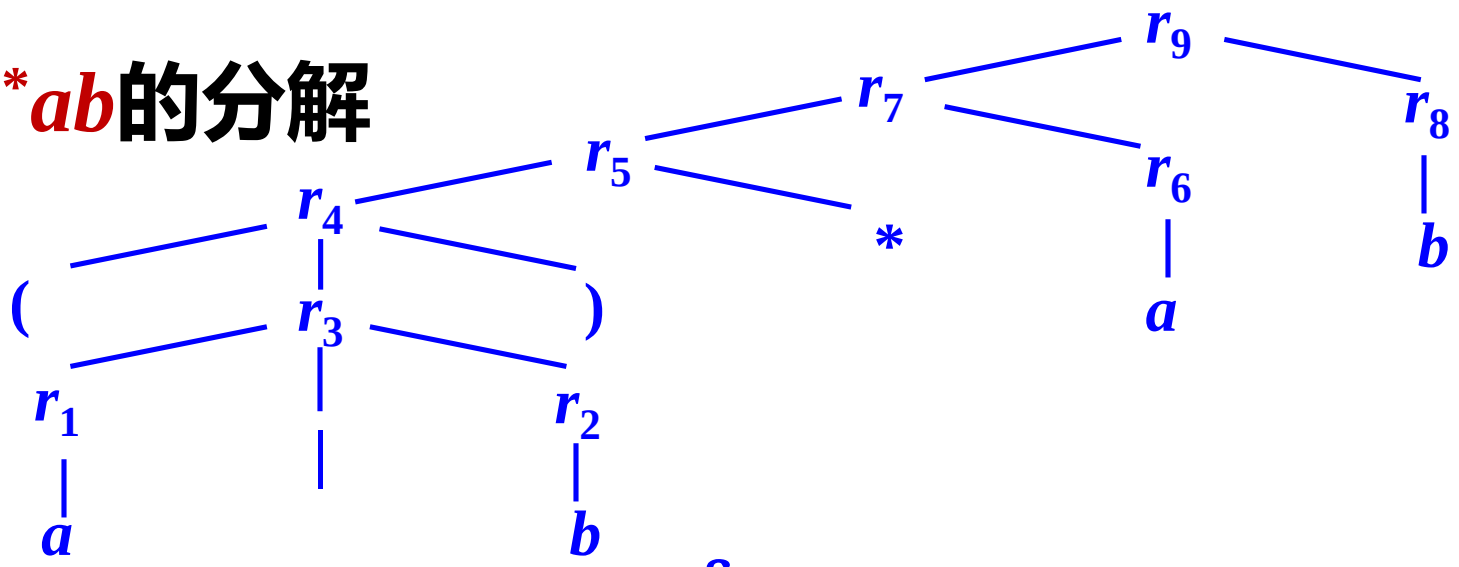
$(a|b)^*ab$的分解

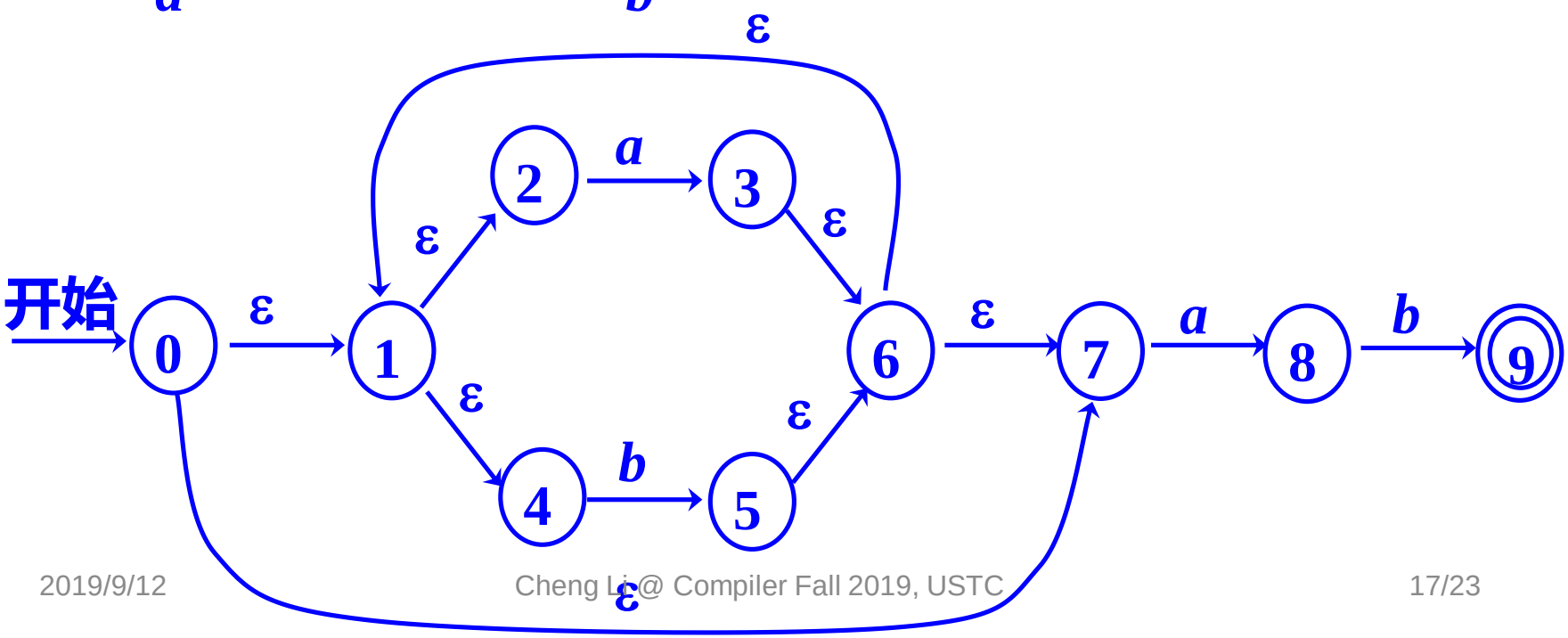




NFA构造过程举例

$(a|b)^*ab$的分解

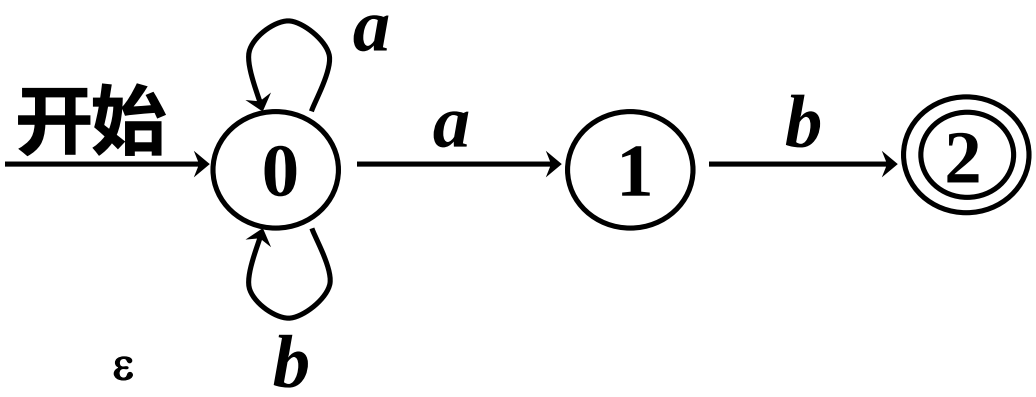




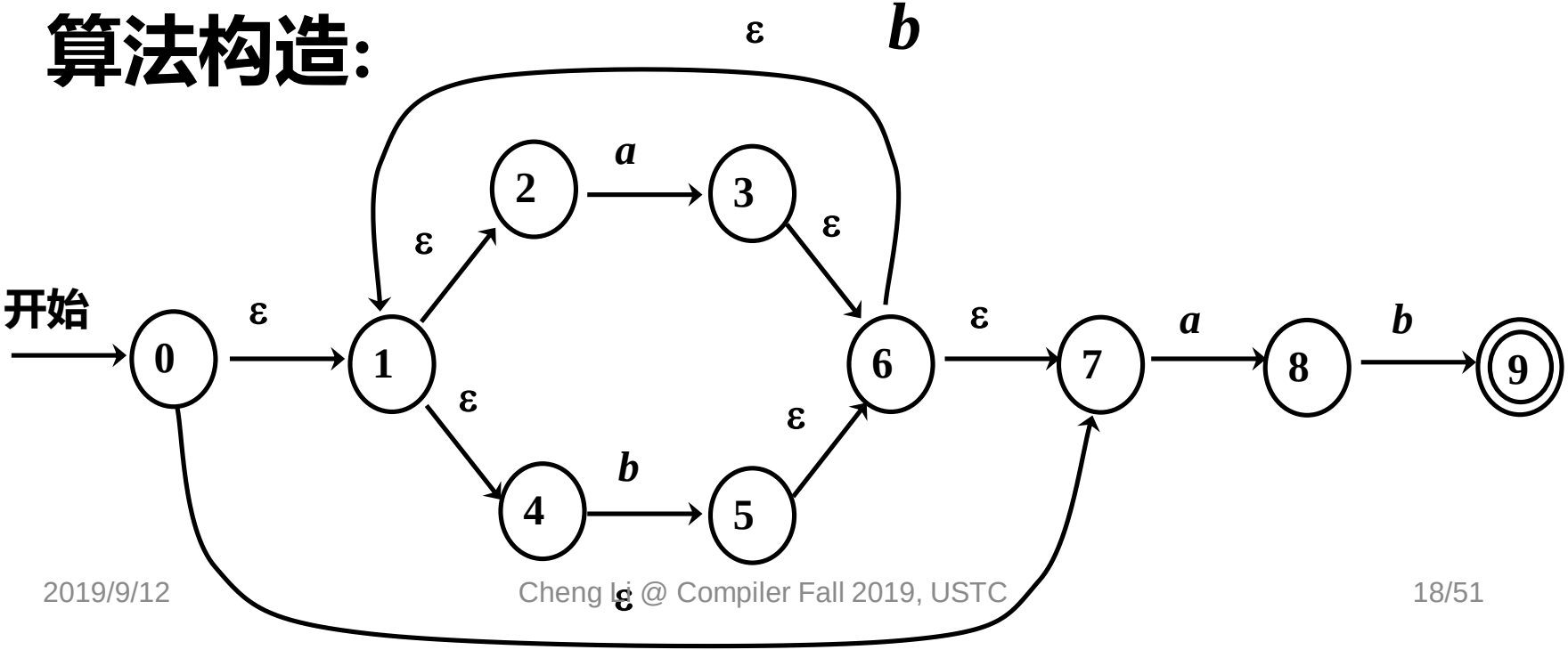
NFA构造过程举例

- (a|b)*ab的两个NFA的比较

手工构造:

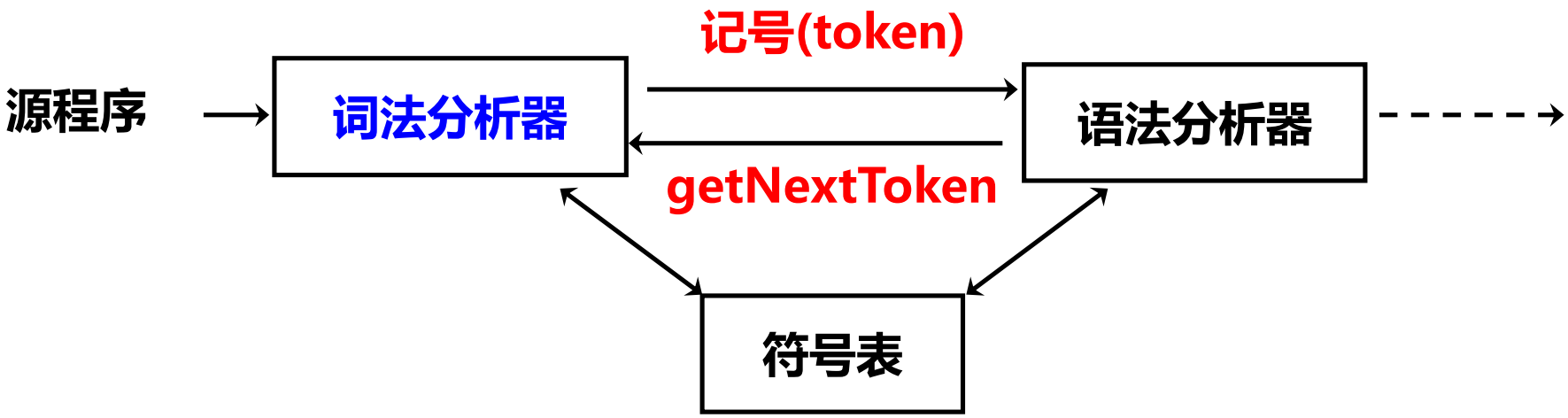


算法构造:



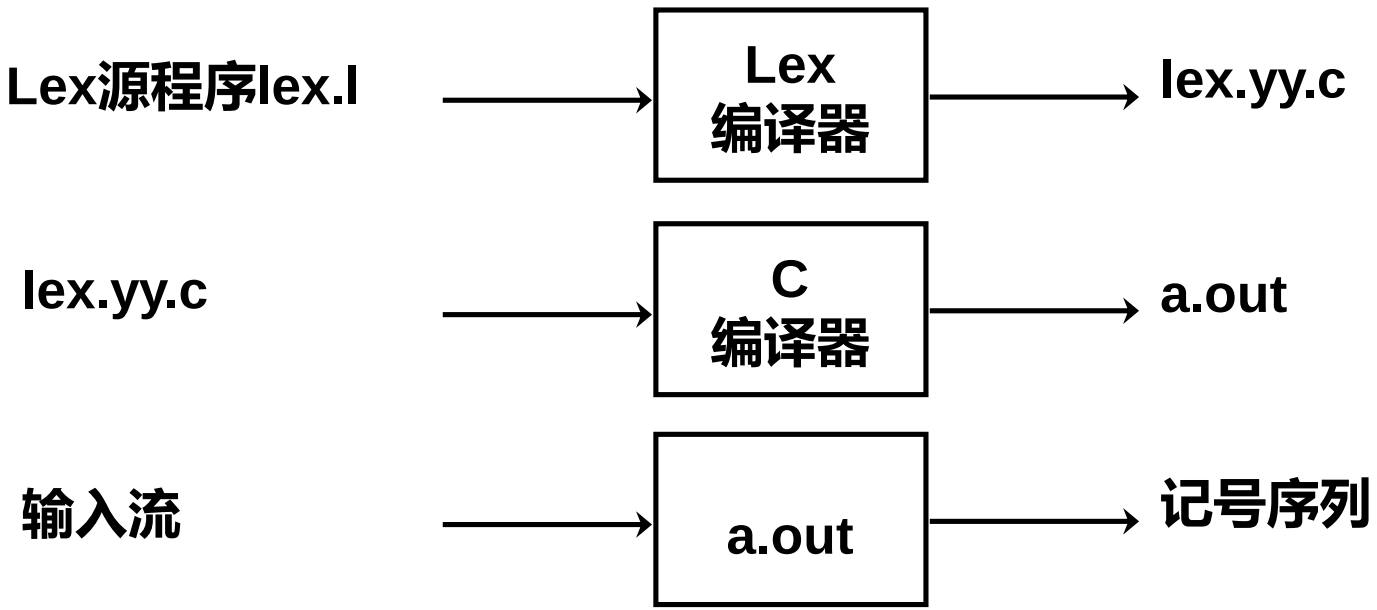
- 从正则表达式建立识别器的步骤
  - 从正则表达式构造NFA（已介绍）
    - 用语法制导的算法，它用正规式语法结构来指导构造过程
  - 把NFA变成DFA （子集构造法，已介绍）
  - 将DFA化简 （合并不可区别状态，也已介绍）

- 正则表达式（a|b）*与（a*|b*）*是否等价?
  - 提示：可利用其最简化DFA的

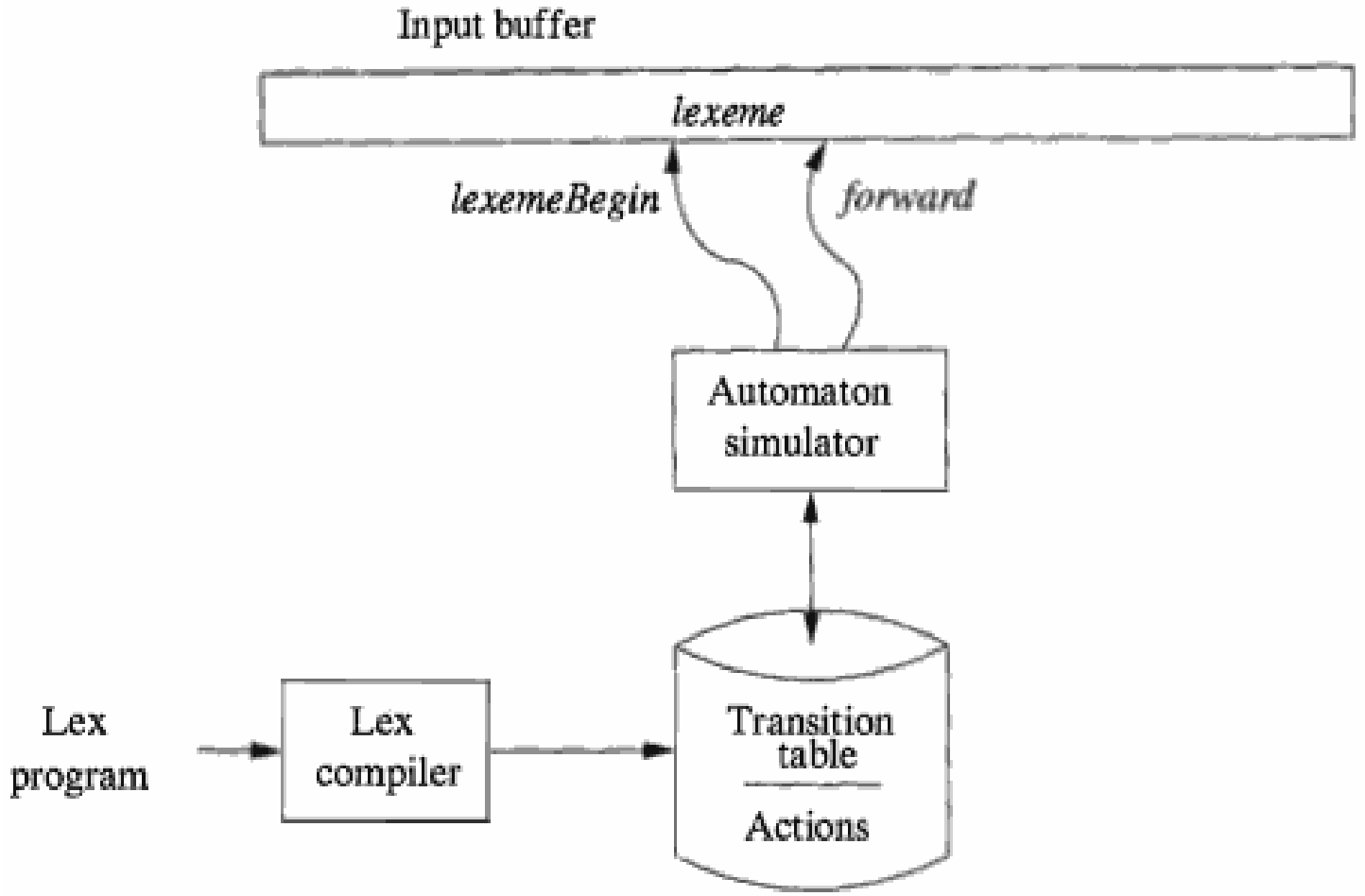


- 词法分析器的自动生成
  - 正则表达式→NFA → DFA →化简的DFA
- **词法分析器的生成器**
  - **Lex: flex、jflex**

❑ 用Lex建立词法分析器的步骤



词法分析器的生成器


Input buffer
lexeme
lexemeBegin
forward
Automaton simulator
Lex program
Lex compiler
Transition table
Actions

- 包括三个部分

声明

%%

翻译规则

%%

辅助过程

- Lex程序的翻译规则

p_1	{动作1}
p_2	{动作2}
…	…
p_n	{动作n}

Lex文件举例—声明部分


```
%{
/*  常量LT, LE, EQ, NE, GT, GE,
    WHILE, DO, ID, NUMBER, RELOP的定义*/
%}

/* 正则定义 */
delim       [  \t \n ]
ws          {delim}+
letter      [A –Za – z]
digit       [0–9]
id          {letter}({letter}|{digit})*
number      {digit}+(\ .{digit}+)?(E[+\–]?{digit}+)?
```

Lex文件举例—翻译规则部分


```
{ws}        {/* 没有动作，也不返回 */}
while       {return (WHILE);}
do          {return (DO);}
{id}        {yylval = install_id ( ); return (ID);}
{number}    {yylval = install_num( );
              return (NUMBER);}
" < "       {yylval = LT; return (RELOP);}
" <= "      {yylval = LE; return (RELOP);}
" = "       {yylval = EQ; return (RELOP);}
" <> "      {yylval = NE; return (RELOP);}
" > "       {yylval = GT; return (RELOP);}
" >= "      {yylval = GE; return (RELOP);}
```

```
installId ( ) {
        /* 把词法单元装入符号表并返回指针。
        yytext指向该词法单元的第一个字符，
        yyleng给出的它的长度          */
}

installNum ( ) {
        /* 类似上面的过程，但词法单元不是标识符而
  是数 */
}
```

- **FLEX tutorial**
  - http://alumni.cs.ucr.edu/~lgao/teaching/flex.html

- 词法分析器的作用和接口，用高级语言编写词法分析器等内容

- 掌握下面涉及的一些概念，它们之间转换的技巧、方法或算法
  - 非形式描述的语言↔正则表达式
  - 正则表达式→ NFA
  - 非形式描述的语言↔ NFA
  - NFA → DFA
  - DFA →最简DFA
  - 非形式描述的语言 ↔ DFA（或最简DFA）

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《编译原理与技术》
词法分析 II

KISS (Keep It Simple, Stupid!)
It is easier to modify a working system than to get a system working.
——Wisdom