CFL Big Picture

Context Free Languages Conclusion

- We have studied the class of context free languages (CFL)
- We saw many different ways to express a CFL
  1. Context Free Grammars
  2. Context Free Expressions. Things like (mu x . a x a)
  3. Push Down Automata

- We showed that some were equally expressive
  - We need non-deterministic PDA to express Context Free Grammars
- Some were easier to use than others to describe some languages

Algorithms

- We studied algorithms to transform one description into another
  1. Context Free Grammar to PDA (Alg 12.7 pg 770)
  2. PDA into Context Free Grammar (Alg 12.8 pp771-772)
- We studied how to transform grammars
  1. To remove ambiguity (layering)
     1. Non-ambiguous languages can have ambiguous grammars
     2. Some languages are inherently ambiguous.
  2. To remove left recursion by factoring
  3. To use uniform a notation - Chomsky Normal Form

Parsing

- We studied how to accept CFL by using parsing methods based upon context free grammars
  - Top down methods - LL(1)
    - Recursive descent
    - Predictive parsers
  - Bottom up methods – LR(1)

Properties

- We saw that Regular Languages have many properties

- Closure properties
  - Union
  - Kleene – star
  - Intersection
  - Complement
  - Reversal
  - Difference

CFL have fewer properties

- Closure properties
  - Union
  - Kleene – star
  - Concat

- But we do have the intersection between CFL and RL produces a CFL

Proving some language is not CF

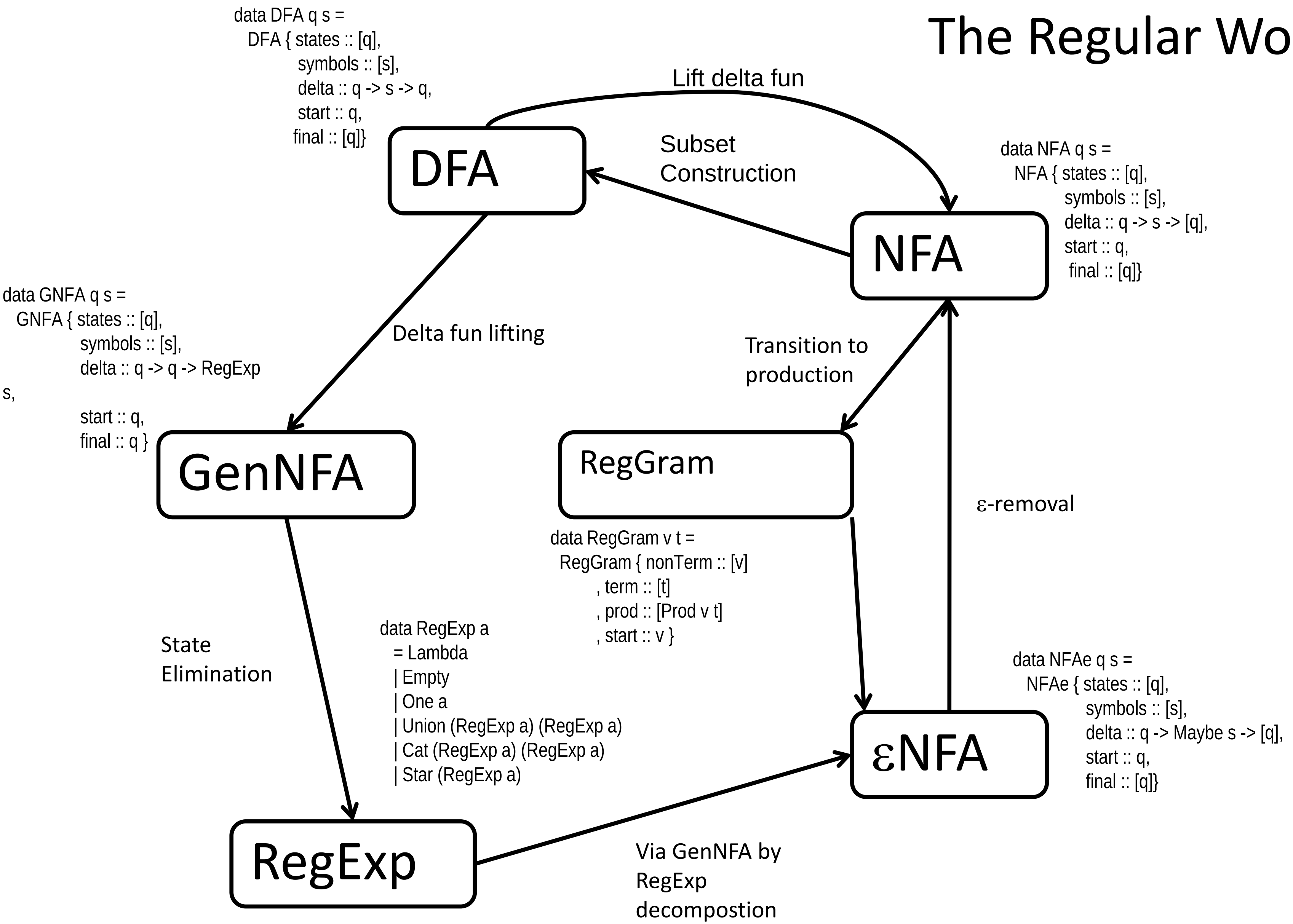
- Pumping lemma for CF languages

- Let L be a CFL. Then there exists a number n (depending on L) such that every string w in L of length greater than n contains a CFL pump.

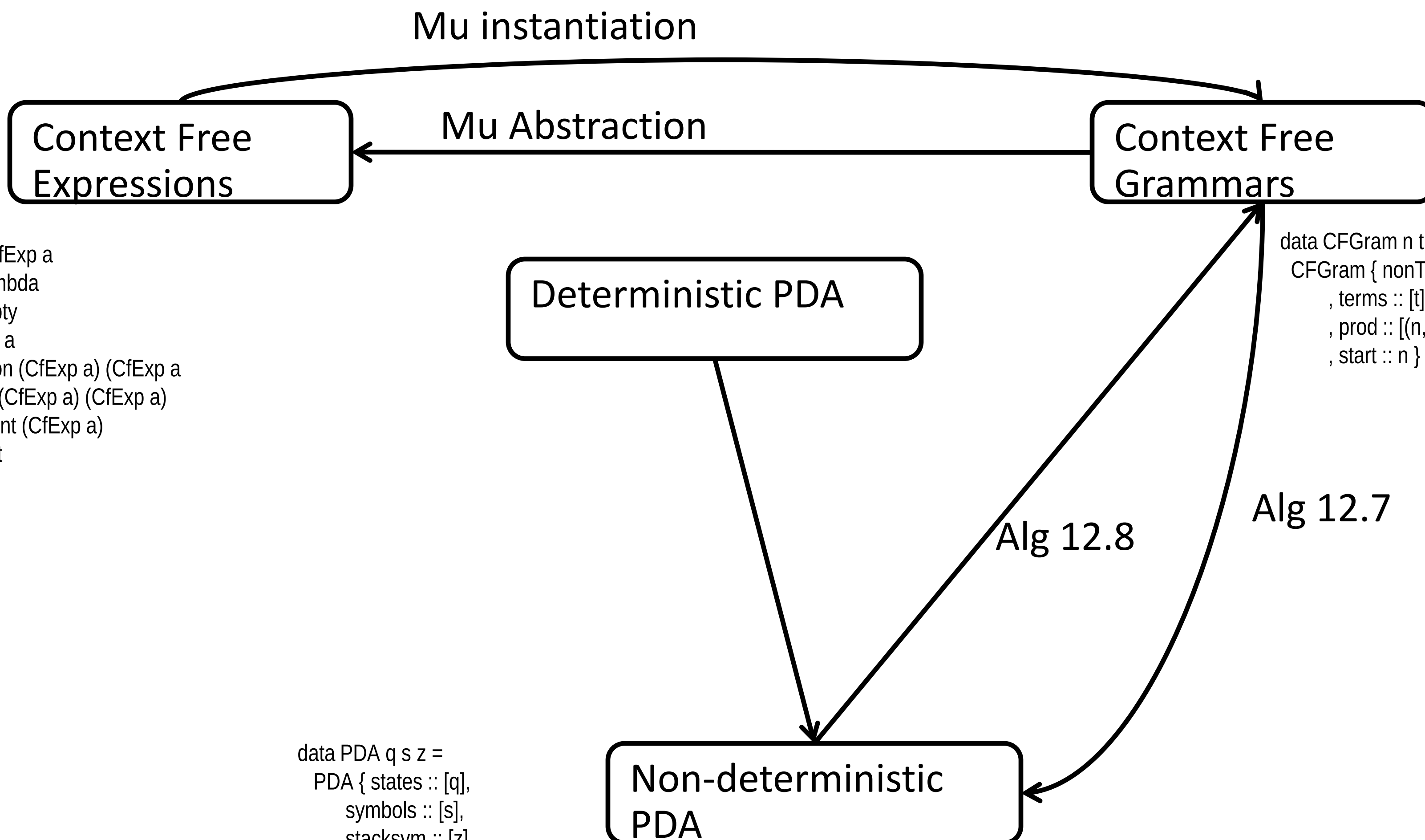
Context Free Pump

- A *CFL pump* consists of two non-overlapping substrings that can be pumped simultaneously while staying in the language.
- Precisely, two substrings u and v constitute a CFL pump for a string w of L (|w| > m) when
  1. $uv \neq \Lambda$ (which means that at least one of u or v is not empty)
  2. And we can write w=xuyvz, so that for every $i \geq 0$
  3. $xu^i yv^i z \in L$

The Regular World



The Context Free World




```
data CfExp a
  = Lambda
  | Empty
  | One a
  | Union (CfExp a) (CfExp a
  | Cat (CfExp a) (CfExp a)
  | Mu Int (CfExp a)
  | V Int
```

```
data CFGram n t =
  CFGram { nonTerm :: [n]
         , terms :: [t]
         , prod :: [(n,[Sym n t])]
         , start :: n }
```

```
data PDA q s z =
  PDA { states :: [q],
        symbols :: [s],
        stacksym :: [z],
        delta ::  [(q,Maybe s,z,[(q,[z])])],
        start :: q,
        final :: [q]}
```

The Larger World