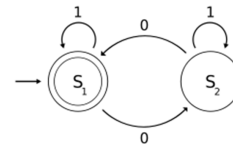


# Regular Languages

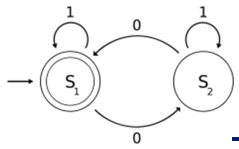
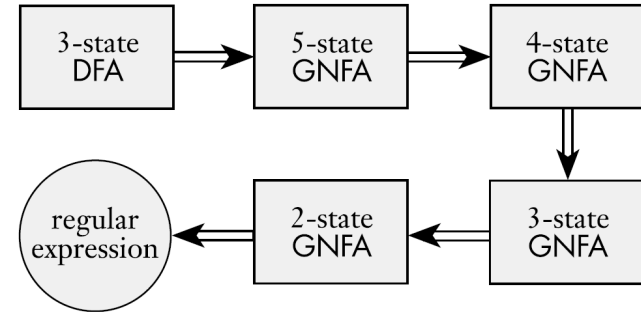
Sipser: Section 1.3 pages 69 - 76



# Generalized Nondeterministic Finite Automaton (GNFA)

**Theorem.** A language is regular if and only if some regular expression describes it.

**Proof.** ( $\Rightarrow$ )

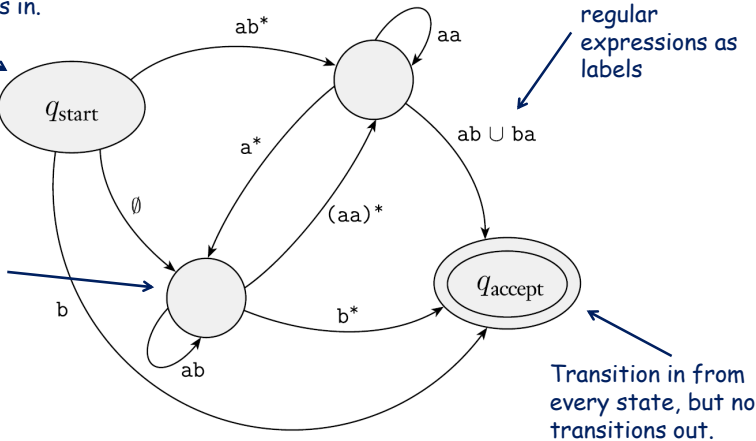


# GNFA Ground Rules

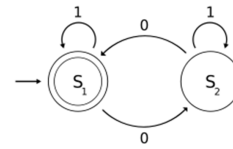
Transition out to every other state, but no transitions in.

Transition arrows have regular expressions as labels

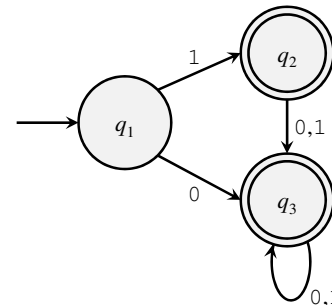
Exactly one arrow from and to every other state other than start or accept.



Transition in from every state, but no transitions out.



# Converting DFA into GNFA

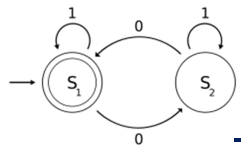


Add new start state with  $\epsilon$  arrow to old start state.

Add new accept state with  $\epsilon$  arrows from old accept states. Remove old accept states.

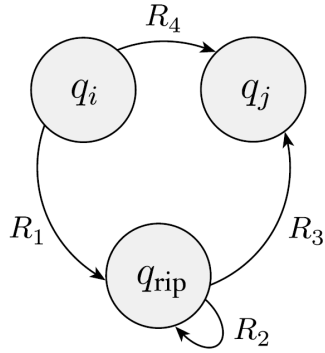
Multiple labels on arrow are replaced by union of labels.

Add arrows labeled  $\emptyset$  between states that had no arrows.

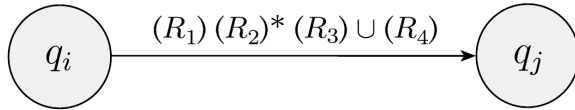


## Ripping Out States

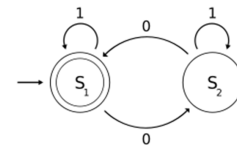
Before



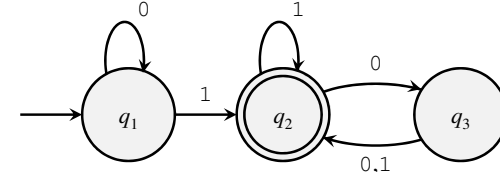
After



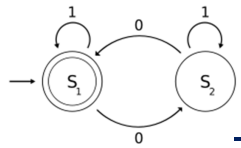
G-5



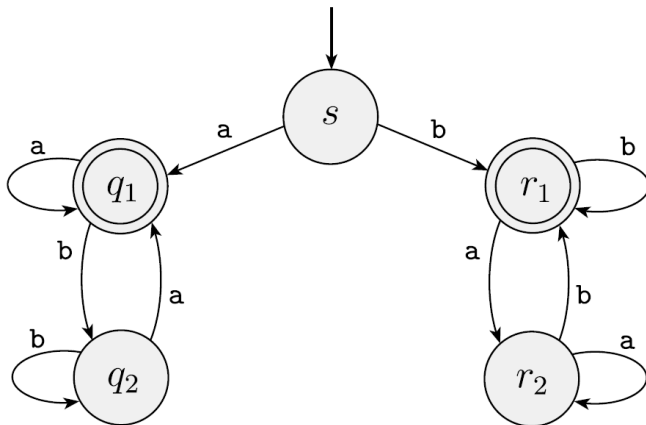
## Regular Expression?



G-6



## A Regular Expression for An Old Friend



G-7