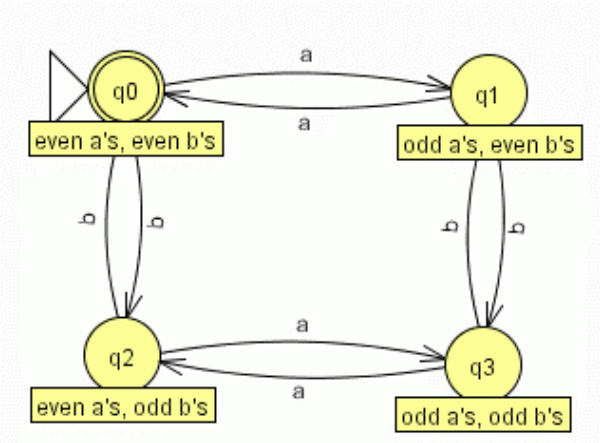
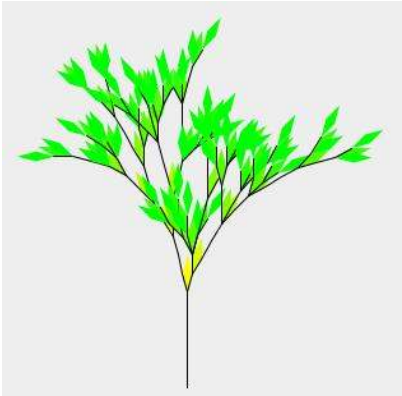
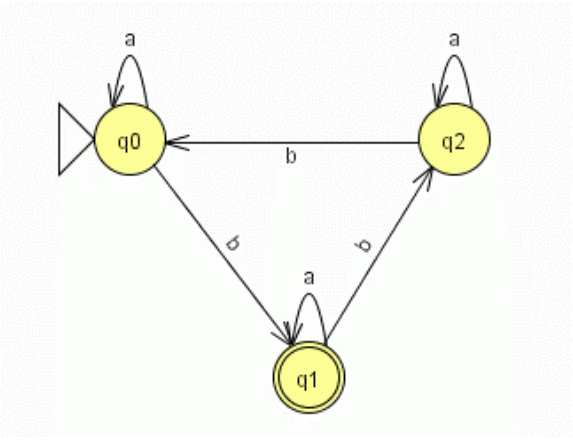
Turning Automata Theory into a Hands-on Course







Susan Rodger, Bart Bressler, and Stephen Reading Duke University	Thomas Finley Cornell University

Thanks to National Science Foundation, grant NSF CCLI-EMD 0442513

Outline

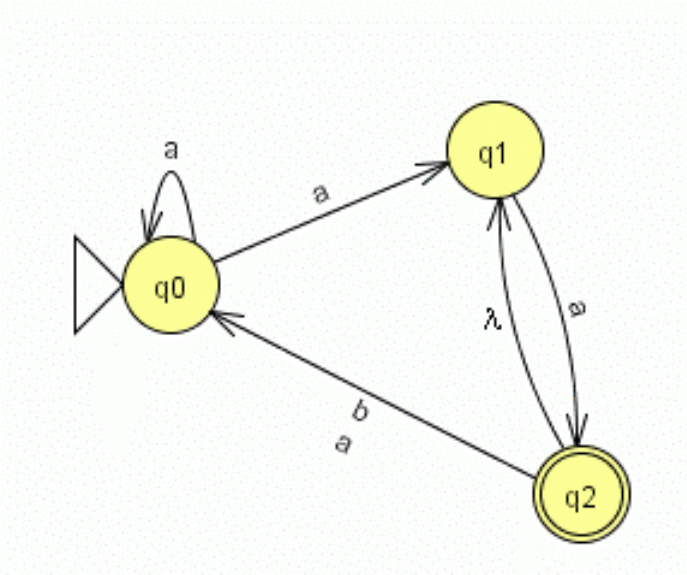
- Overview of JFLAP
- Problem Solving with JFLAP
- New Feature:
  - Turing Machine Building Blocks
- JFLAP's Use
- Future Work

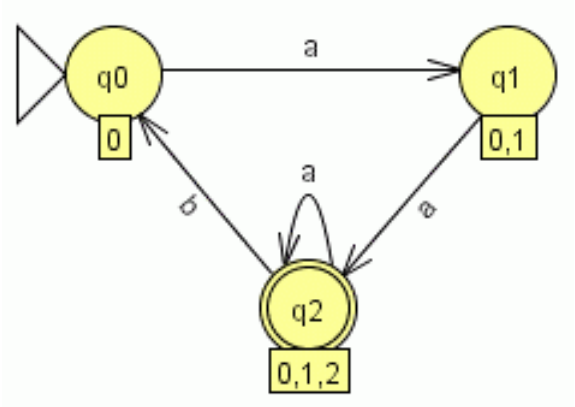
JFLAP History

- 1990 - Started as NPDA
- 1991 – LL, LR parser
- 1991 – FLAP
- 1996 – JFLAP
- Thanks to Many Students!
  - Caugherty, James, Blythe, LoSacco, Luce, Wolfman, Ramm, Leider, Salemme, Bilska, Badros, M. Procopiuc, O. Procopiuc, Cavalcante, Hung, Grammond, Geer, Karweit, Hardekopf, Bressler, Reading, Finley

JFLAP – Regular Languages

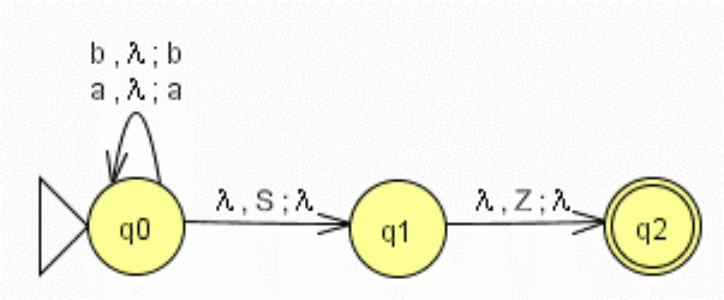
- Create
  - DFA and NFA
  - regular grammar
  - regular expression
- Conversions
  - NFA to DFA to minimal DFA
  - NFA ←→ regular expression
  - NFA ←→ regular grammar



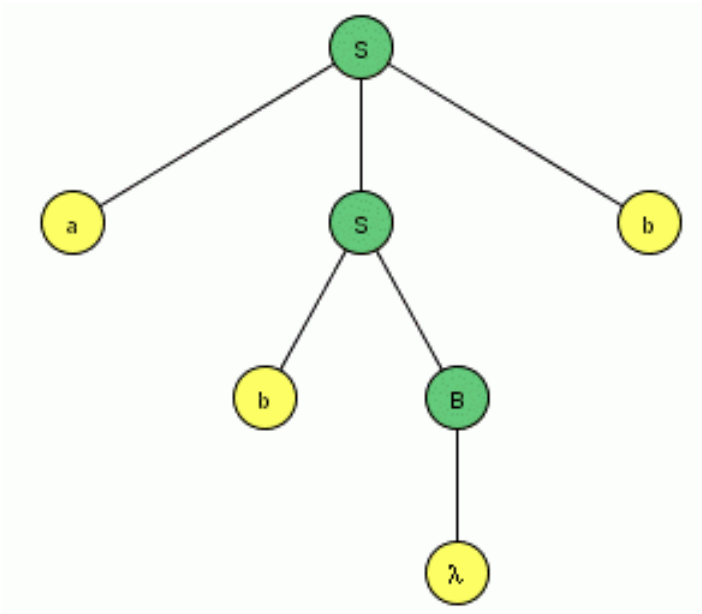


JFLAP – Context-free Languages

- Create
  - Nondeterministic PDA
  - Context-free grammar

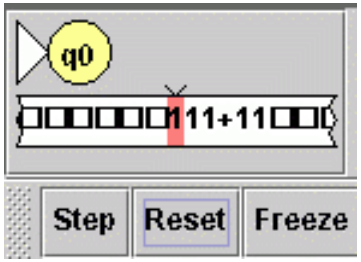


- Transform
  - PDA → CFG
  - CFG → PDA (LL & SLR parser)
  - CFG → CNF
  - CFG → Parse table and Parsing
    - (LL and SLR parsing)
  - CFG → Brute Force Parser

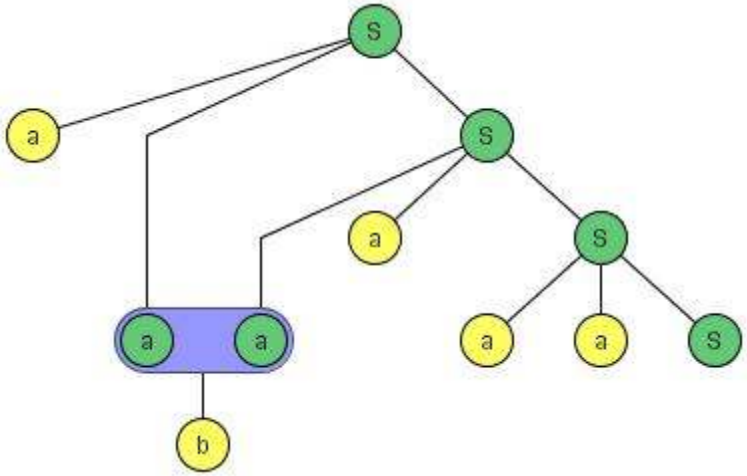


JFLAP – Recursively Enumerable Languages

- Create
  - Turing Machine (1-Tape)
  - Turing Machine (multi-tape)
  - Building Blocks
  - Unrestricted grammar



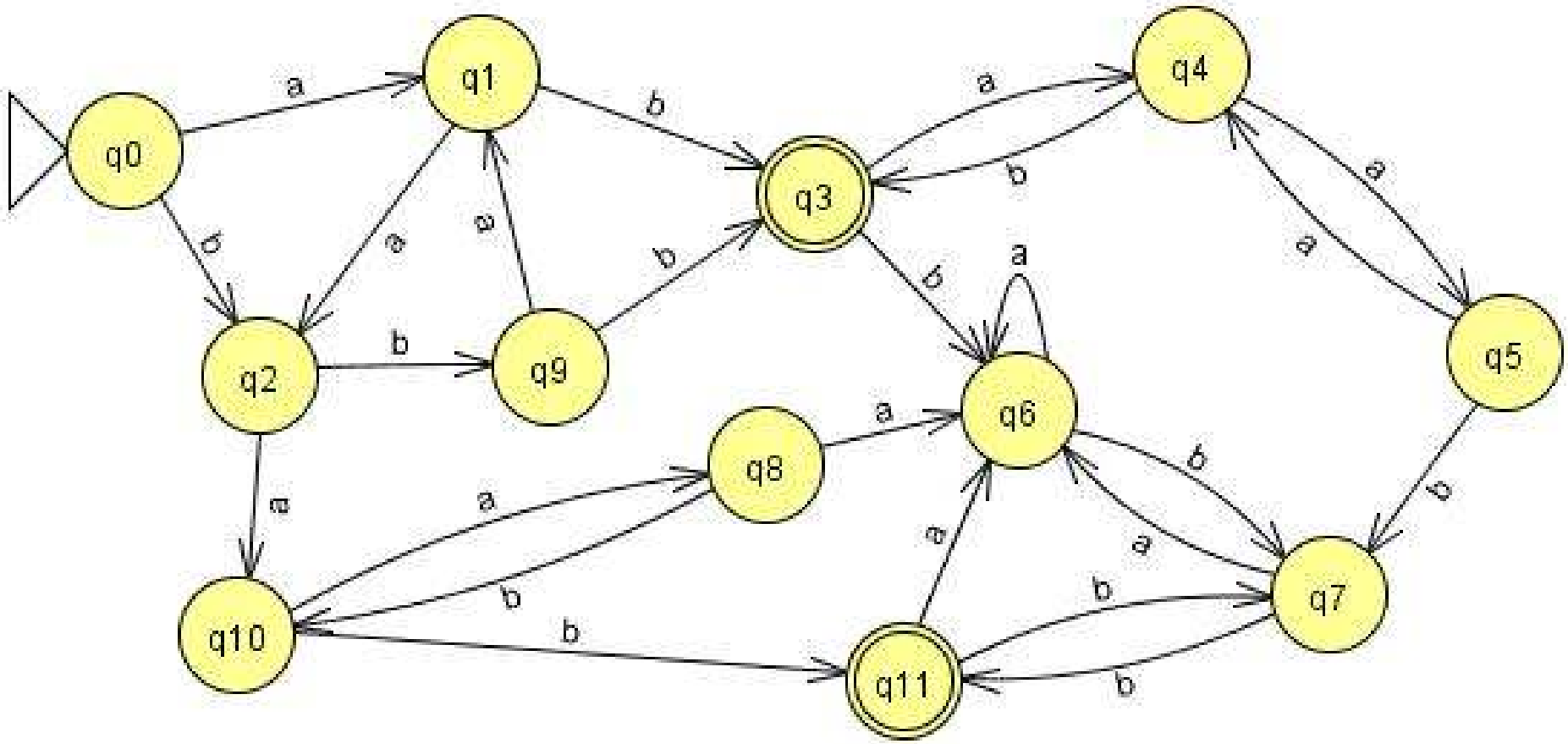
- Parsing
  - Unrestricted grammar with brute force parser



Problem Solving with JFLAP

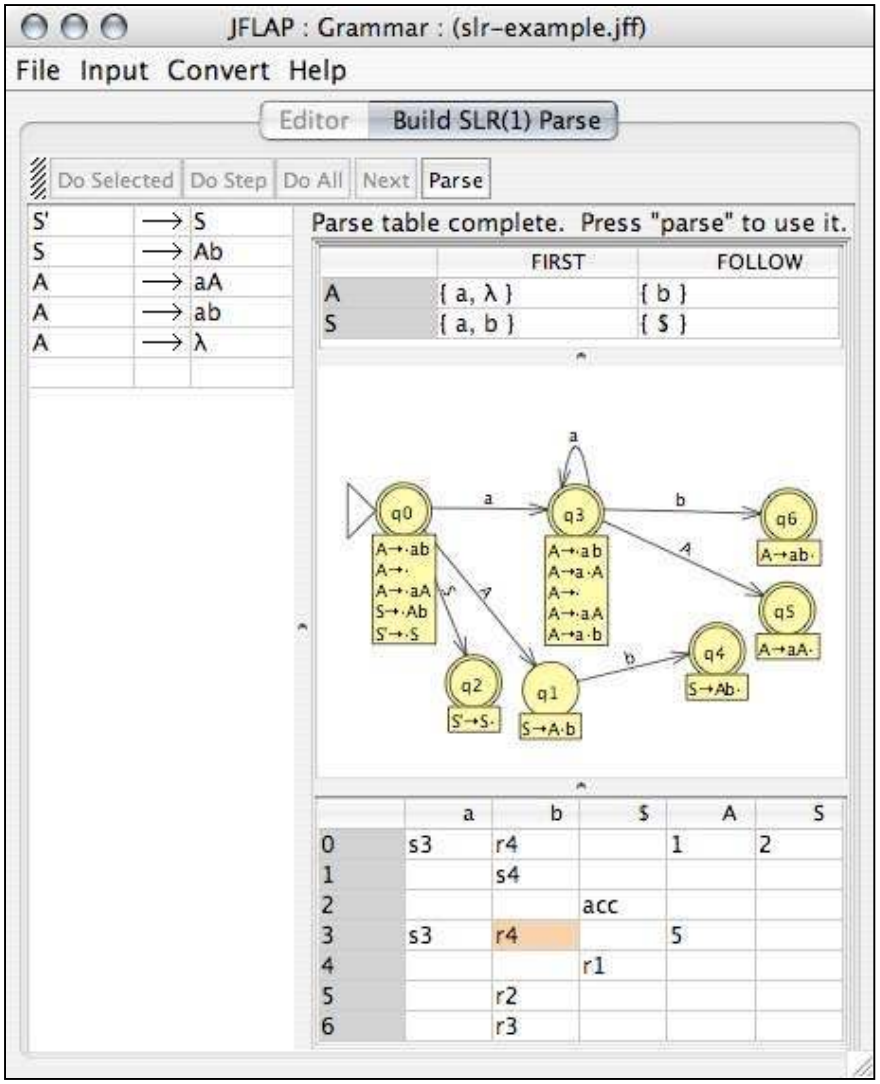
- Example: How to determine distinguishable states?
- Follow algorithm in JFLAP - DFA to min DFA
- Alternatively, find strings that distinguish two states
  - Make a copy of DFA
  - For each of the two states
    - Make state initial
    - Run on string

States q1 and q4 on ababb



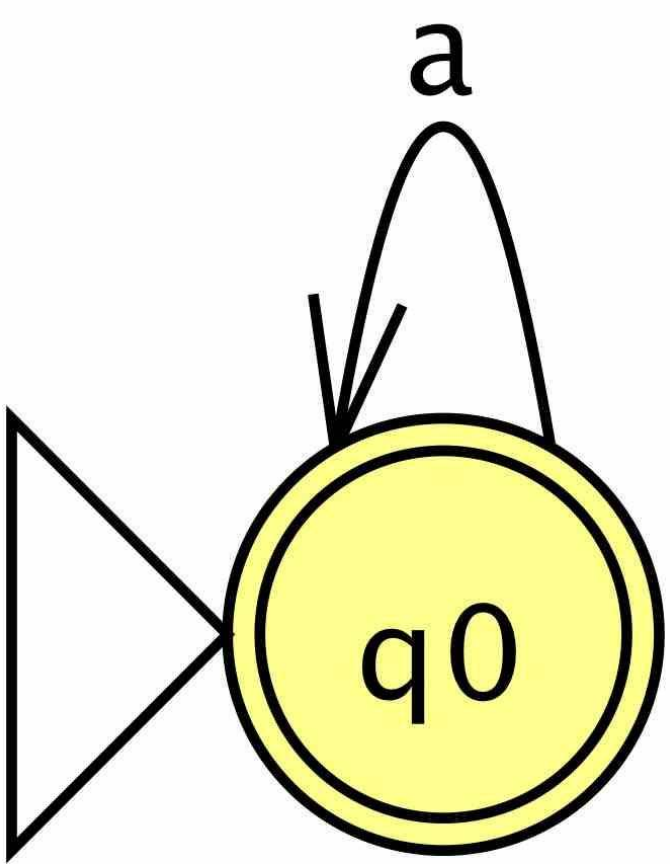
Instant feedback

- Student performs an algorithm (e.g., SLR(1))
- JFLAP provides feedback.
- Avoid “misconception fester” in a student’s mind.

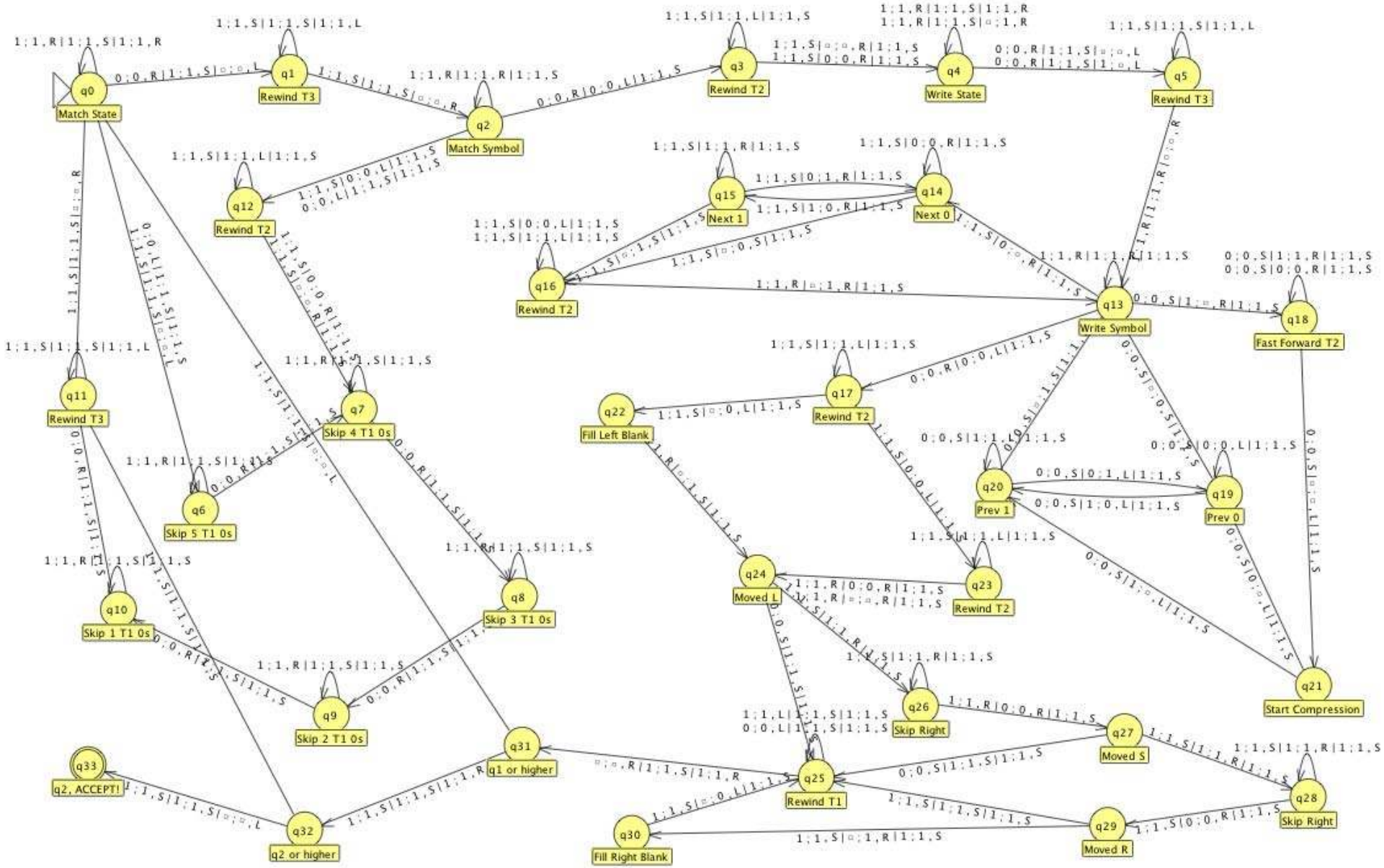


Extend the reach of examples

- Lecture use is helpful.
- Examples by hand often so simple they're unhelpful. To wit:
- Makes slightly more complex examples practical, like…



Universal Turing machine

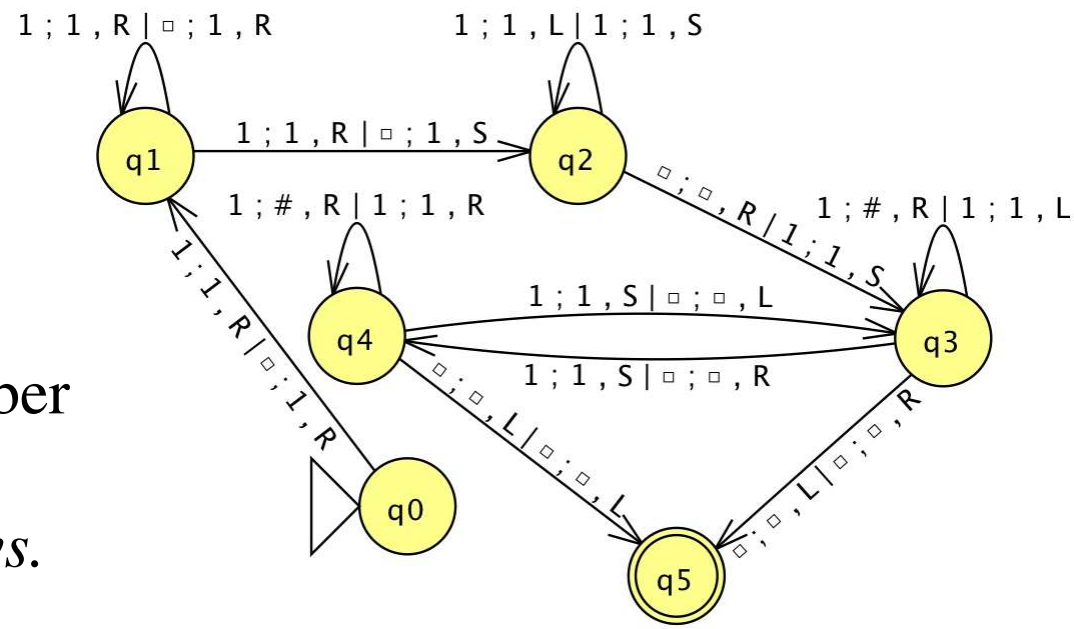


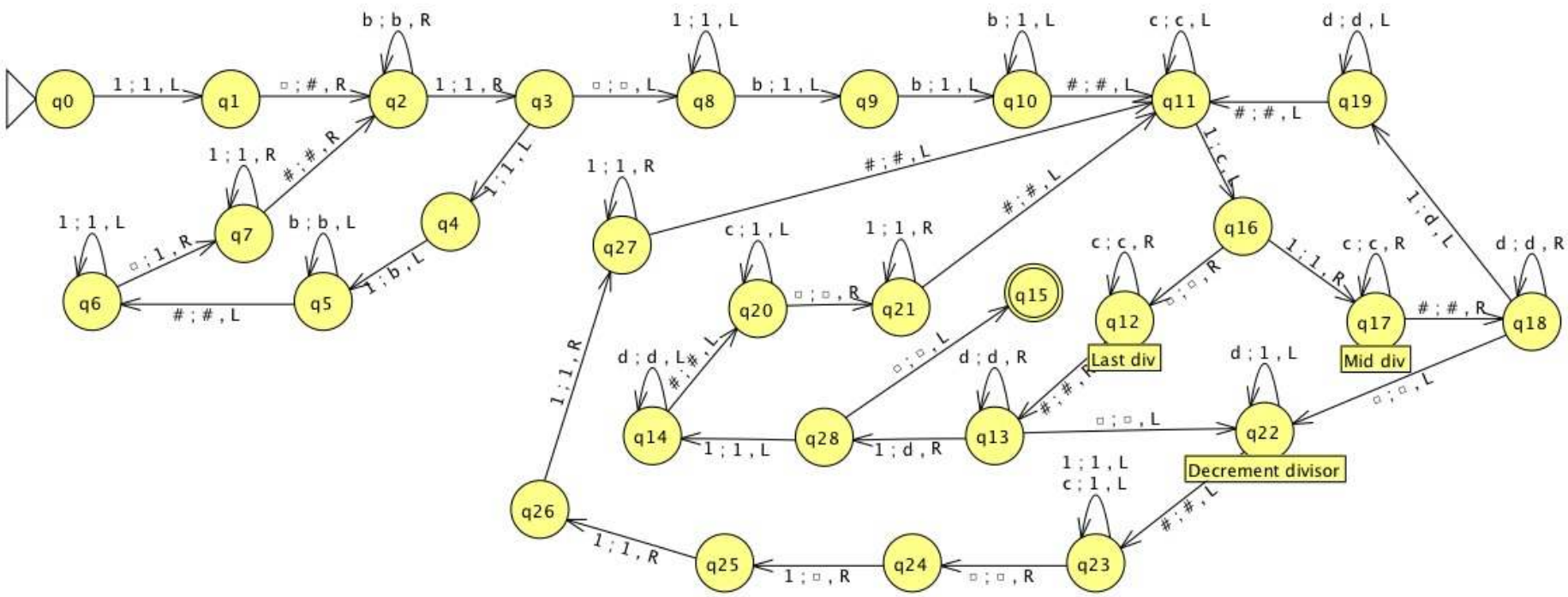
Illustrate simplicity

Determine if a unary number is composite.

2 Tape Nondeterministic vs.

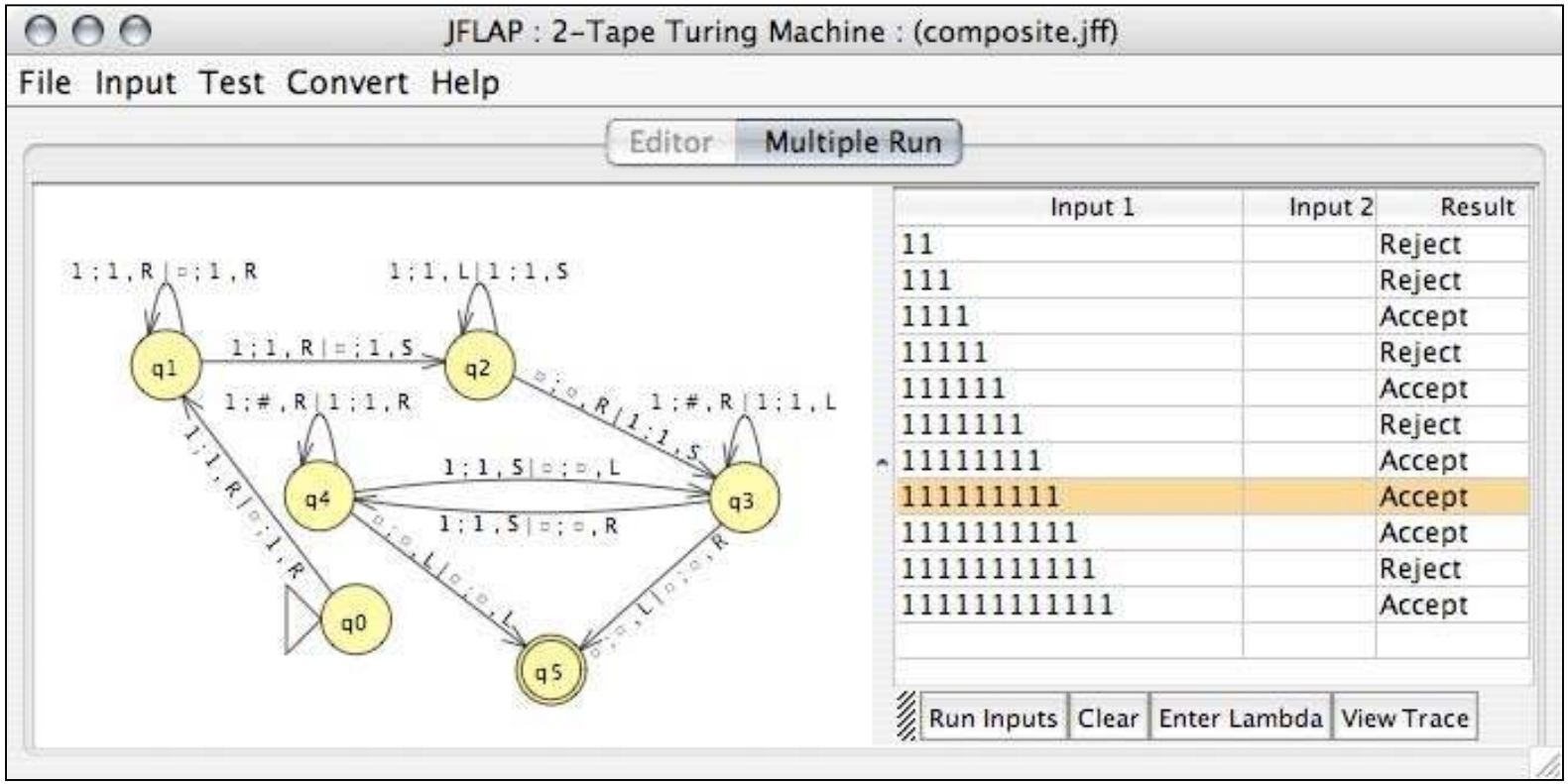
1 Tape Deterministic





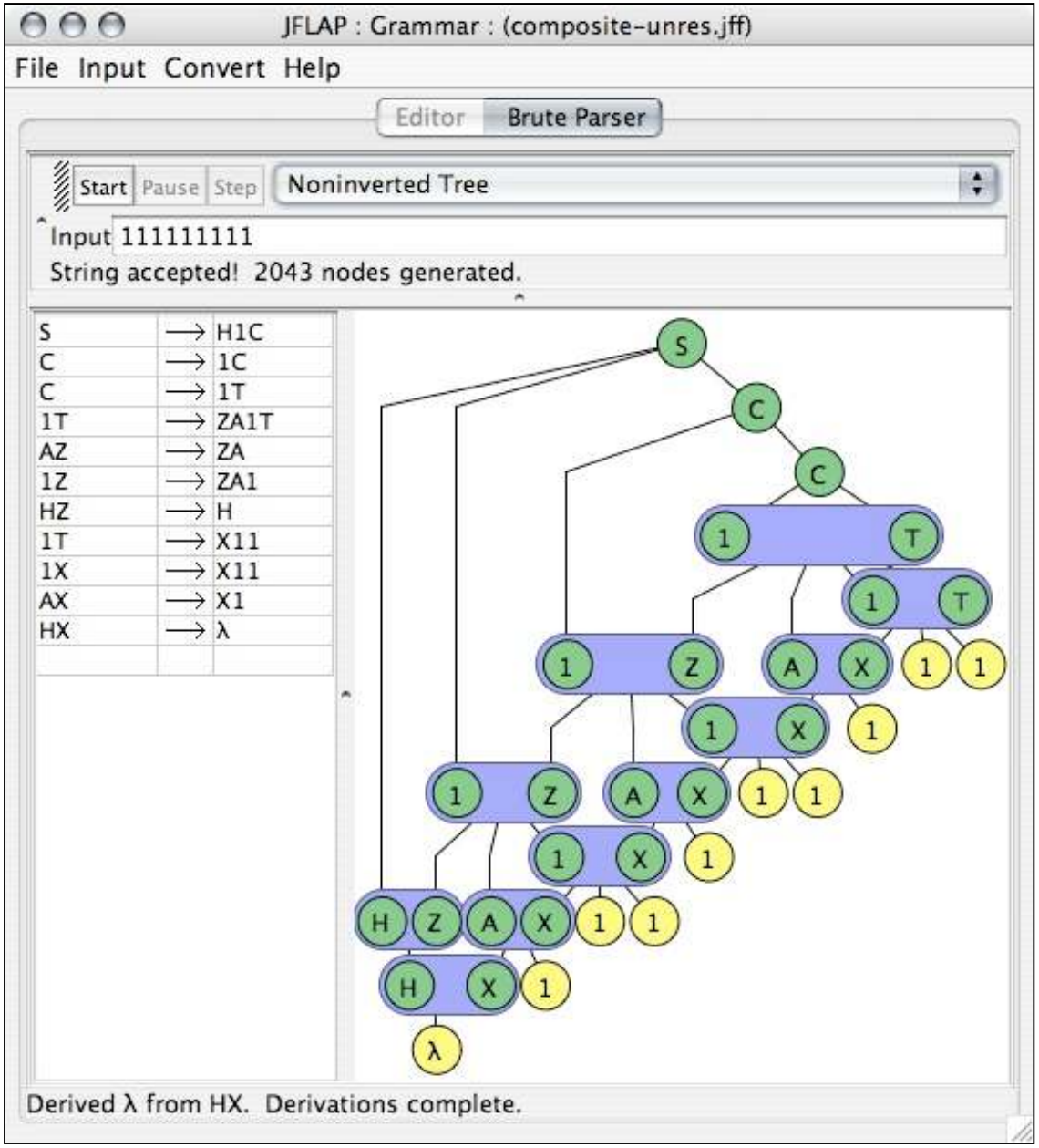
Illustrate simplicity of representation

- Run multiple inputs (pictured), or step through an individual input while viewing configurations.



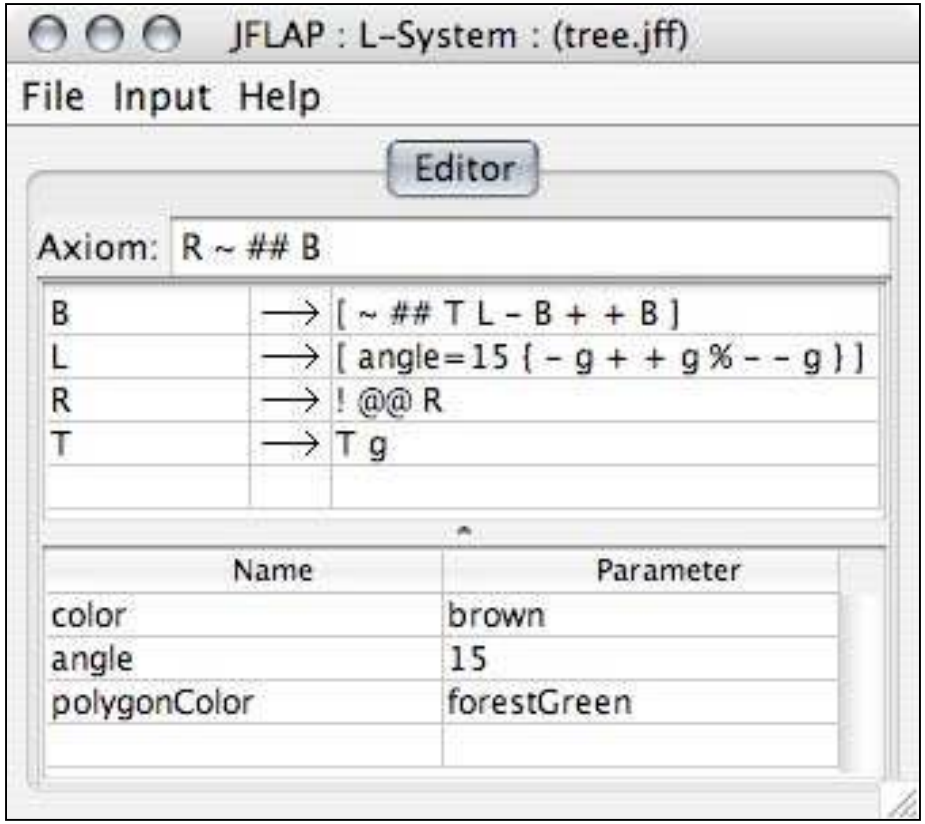
Illustrate alternate representations

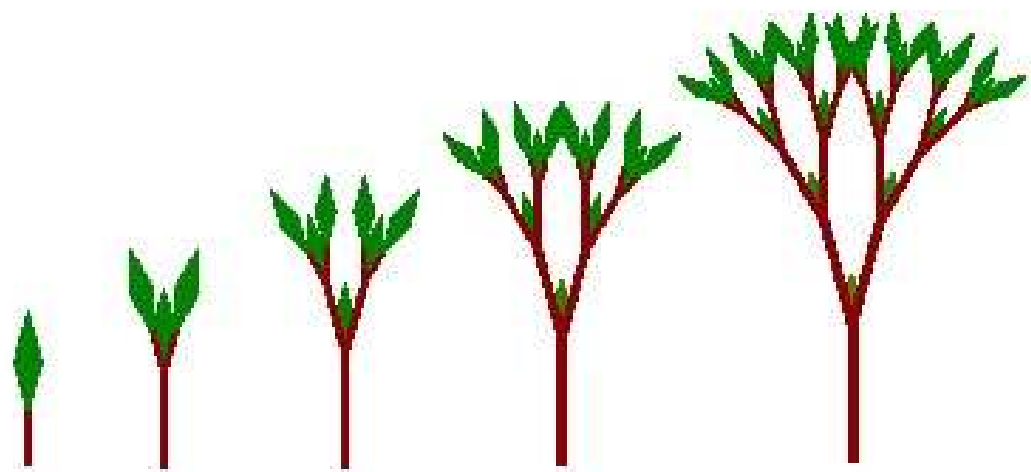
Composite unary numbers as the language of an unrestricted grammar.



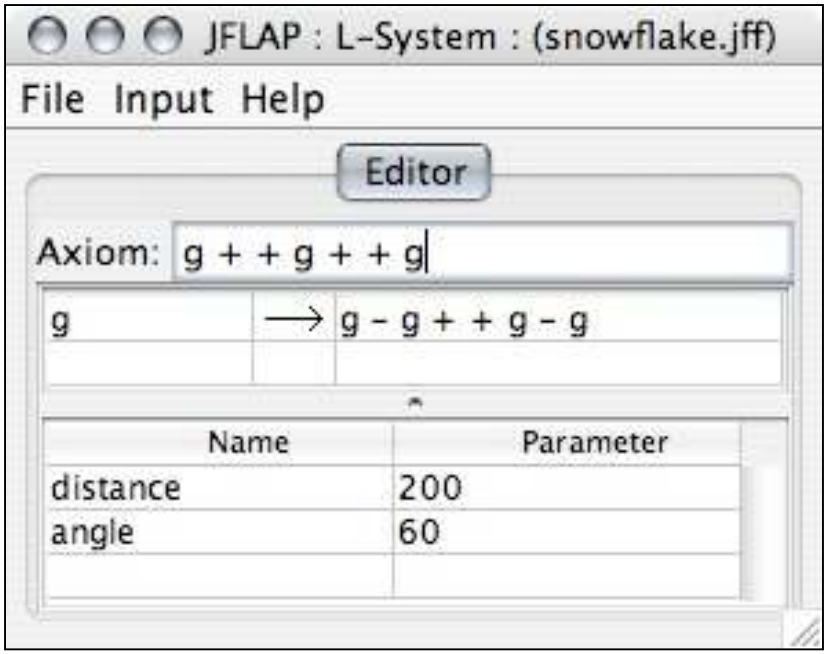
L-Systems

- Formal language construct similar to grammars.
- Original created to model growth of plants.
- Their “pretty-ness” is motivating!

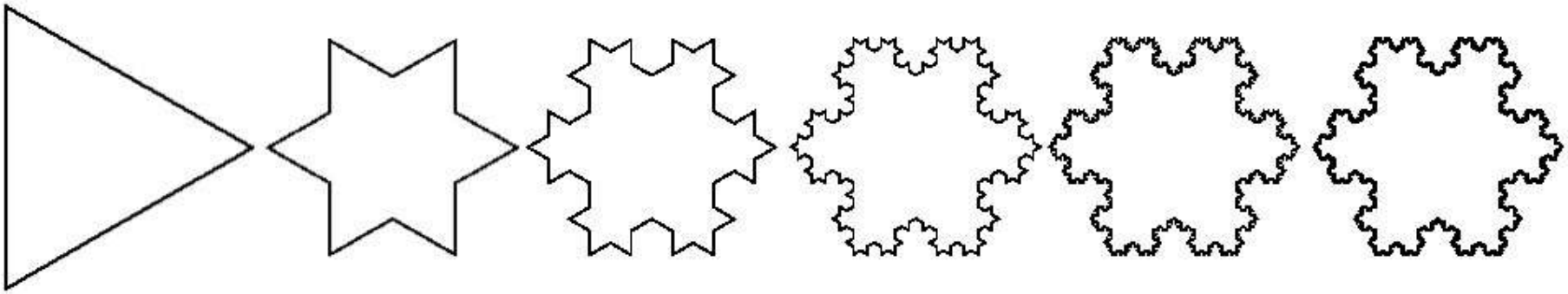




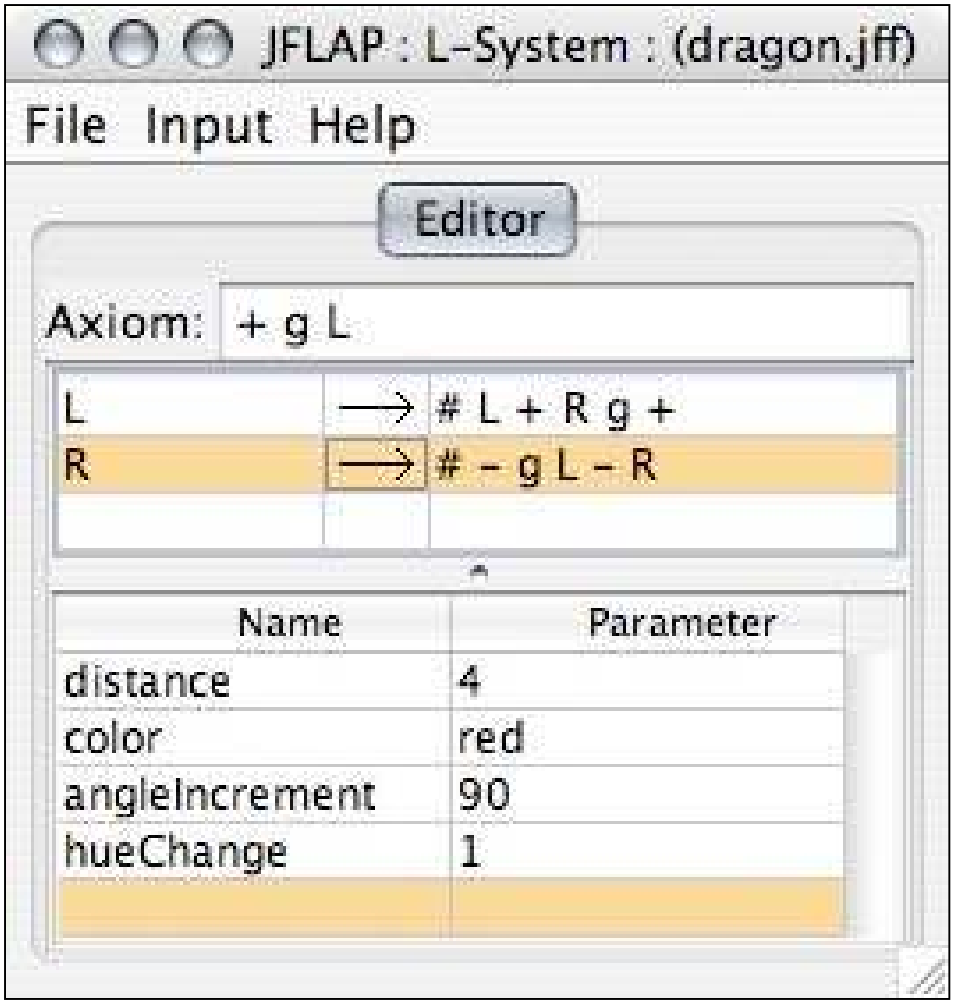
Fractals with L-Systems



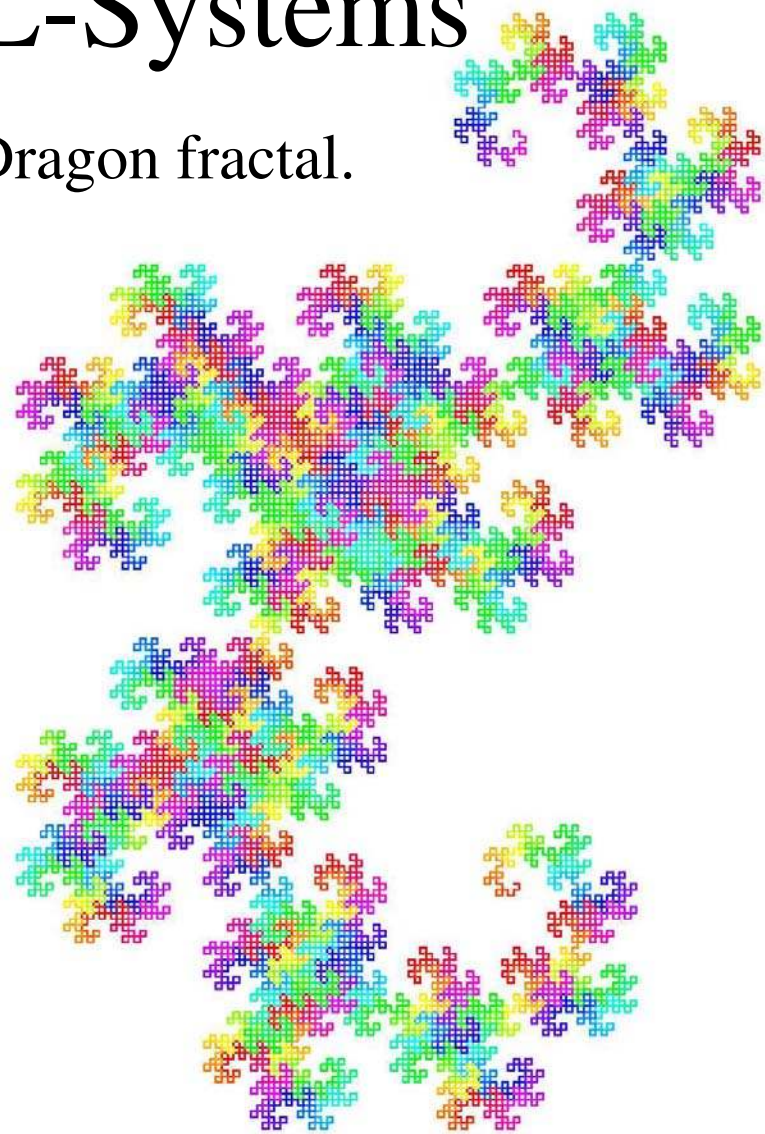
Koch snowflake fractal is pictured here.



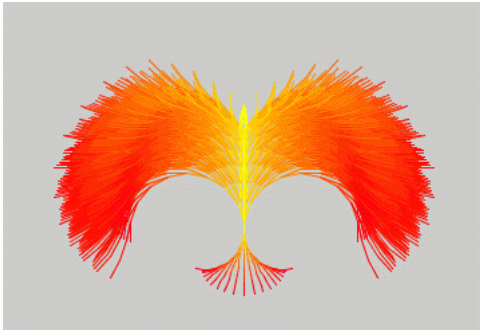
Fractals with L-Systems

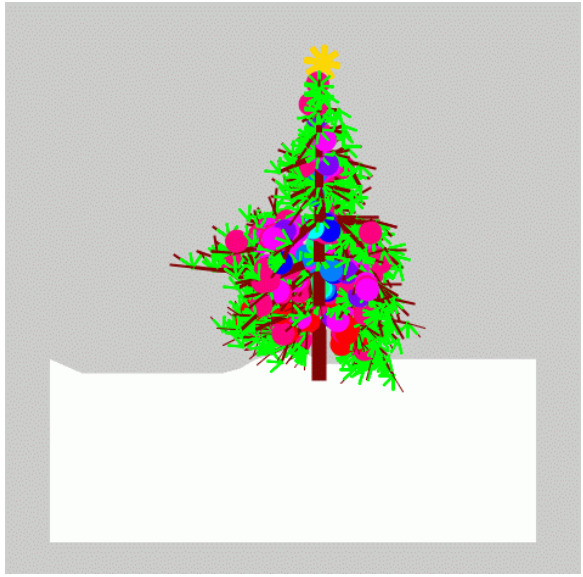


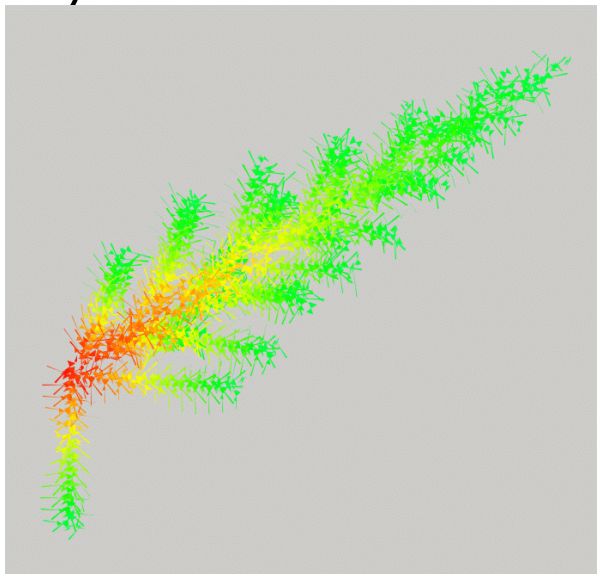
Dragon fractal.

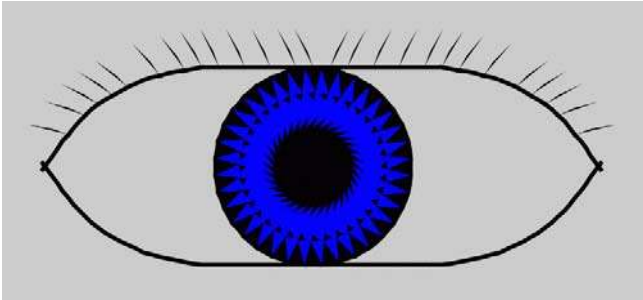


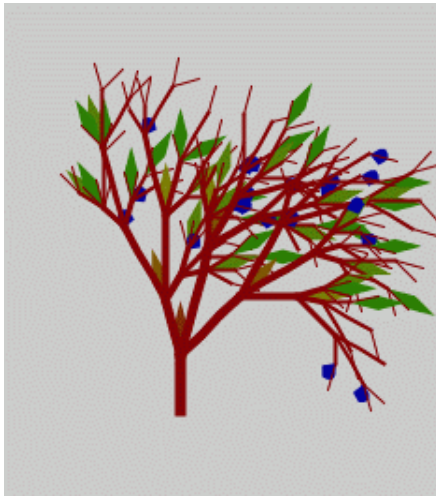
Students like L-systems

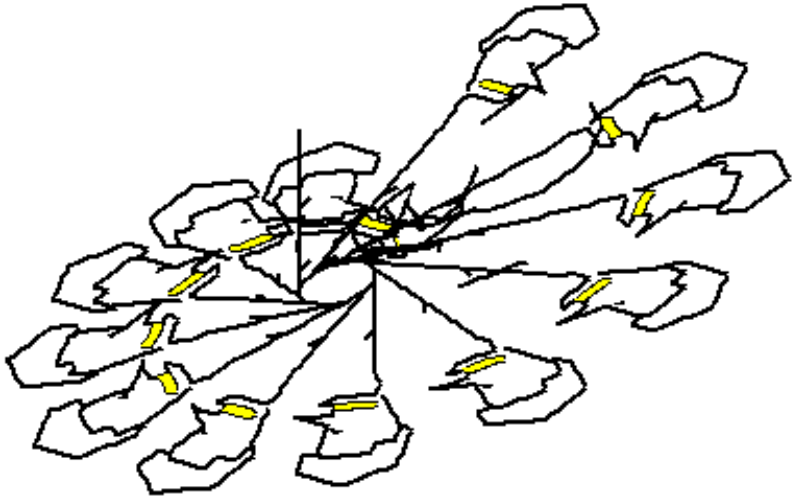






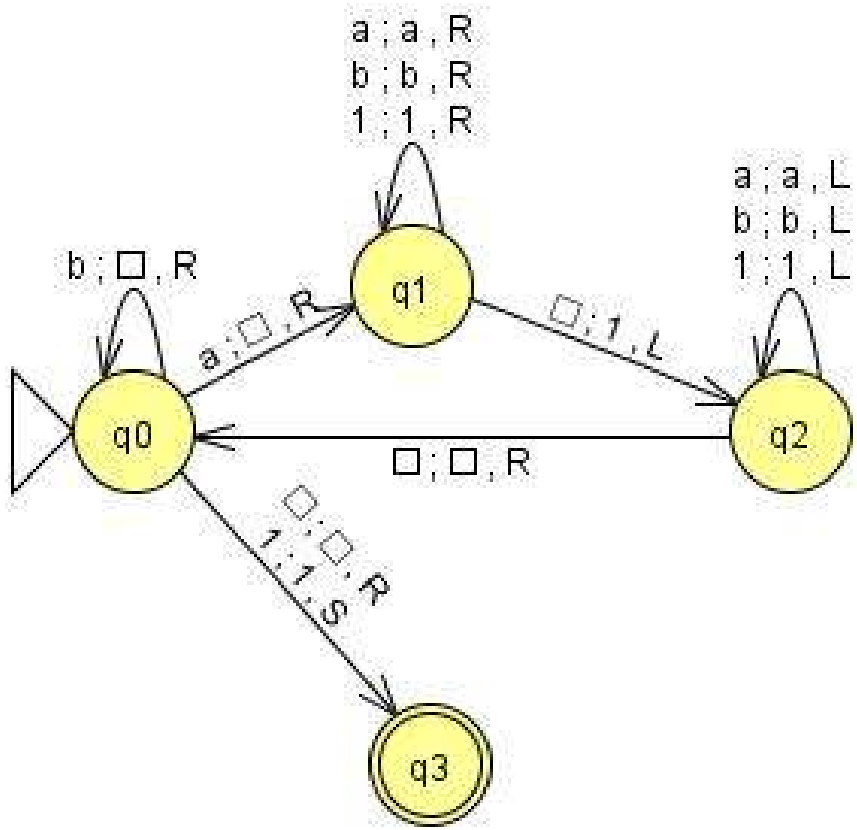






Turing Machine Building Blocks

- First, a problem.
- f(w) = number of a's in w, $\Sigma = \{a,b\}$
- Examples:
  - f(aabab) = 111
  - f(bbbaab) = 11



Turing Machine Building Blocks

- Building Block
  - Build a Turing machine with a specific purpose
  - Name it and save it
  - Use it as a BlackBox in another Turing machine
- Special Symbols

  ~ ignore read or write

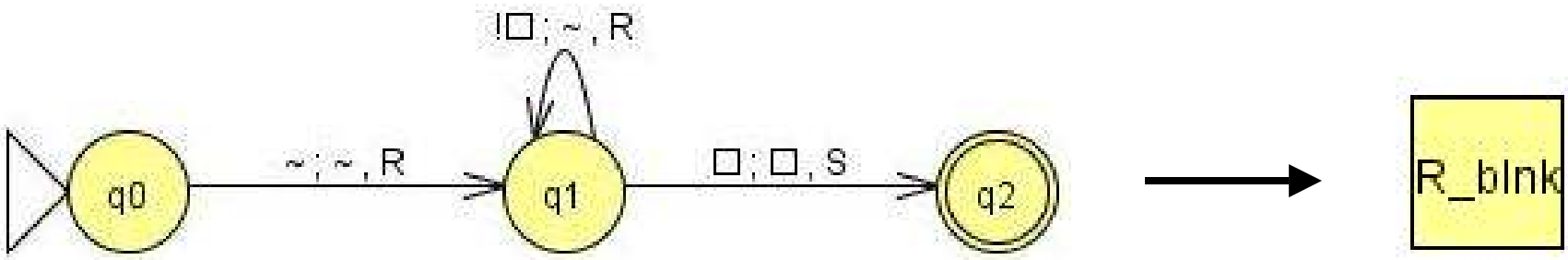
  !x matches all symbols except for x

Simple Building Blocks

- start

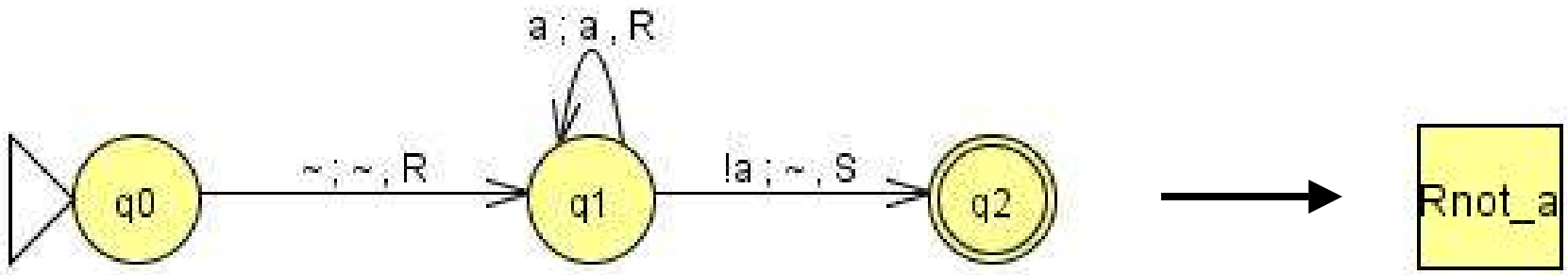
- R – move right

- R_blnk – move right once, keep moving right until reach a blank

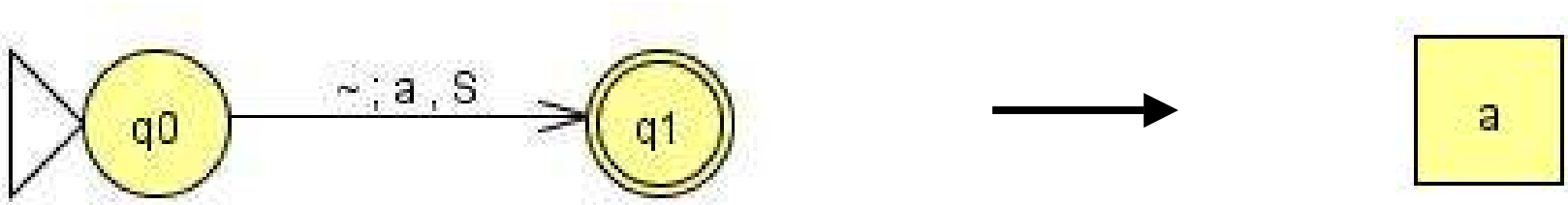


Simple Building Blocks (cont)

- R_not_a – move right once, keep moving until not an “a”

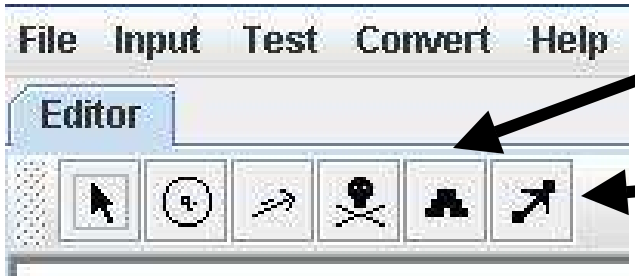


- a - write “a” and stay put



Create & Combine Building Blocks

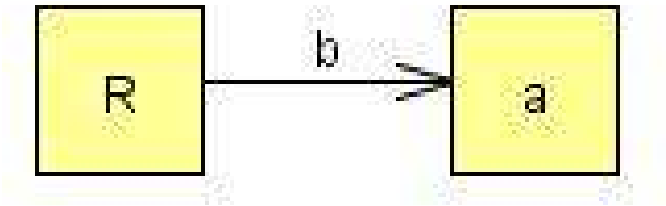
- New Buttons



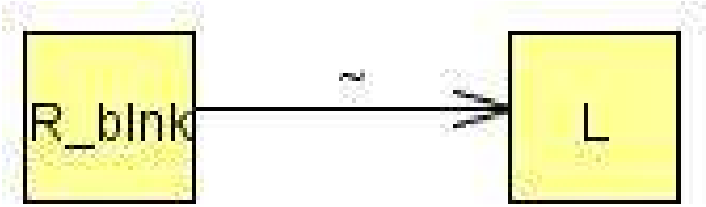
Load BB

BB transition

- Conditional – if the current symbol is b, move to the next block (tape head not moving)

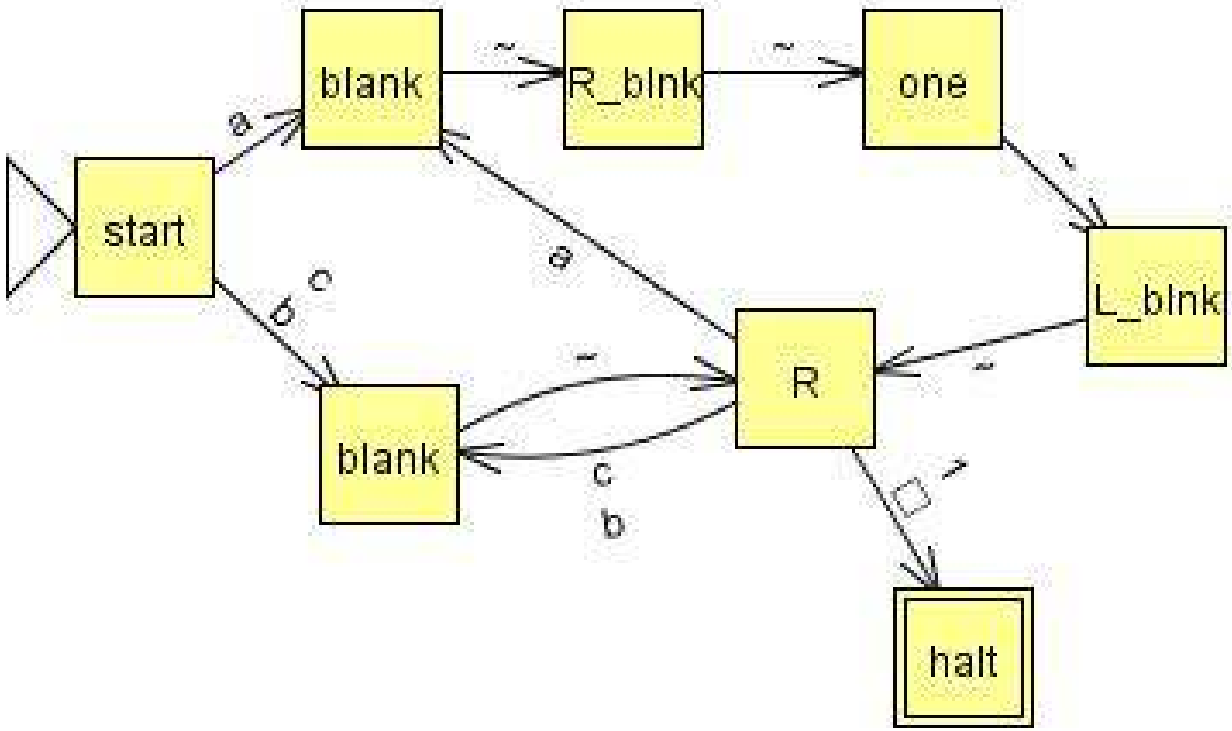


- Move to the next block – use ~
  - Ignore read, ignore write, stay put

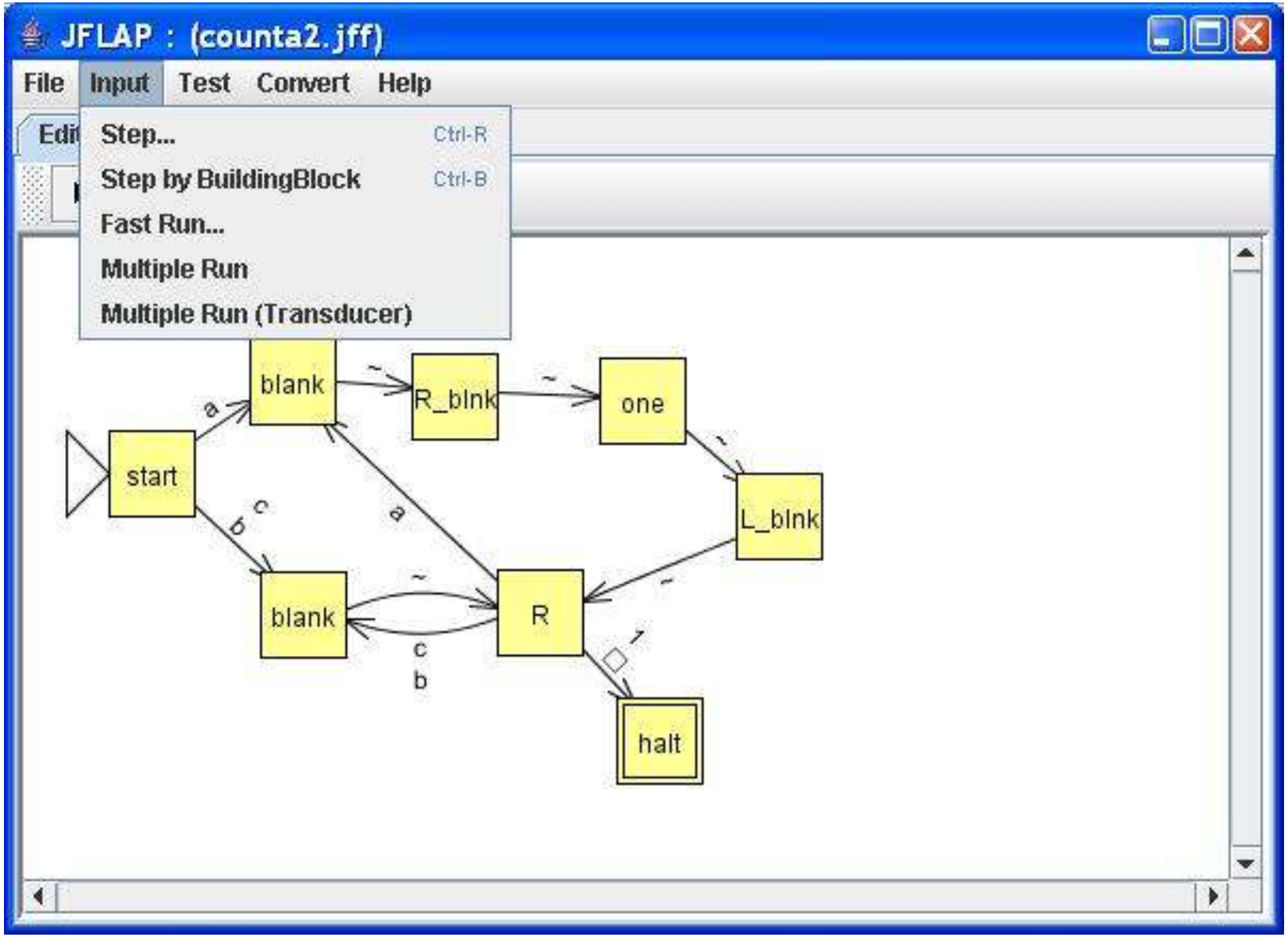


Problem again: Count number of a's

- F(abbaabb) = 111

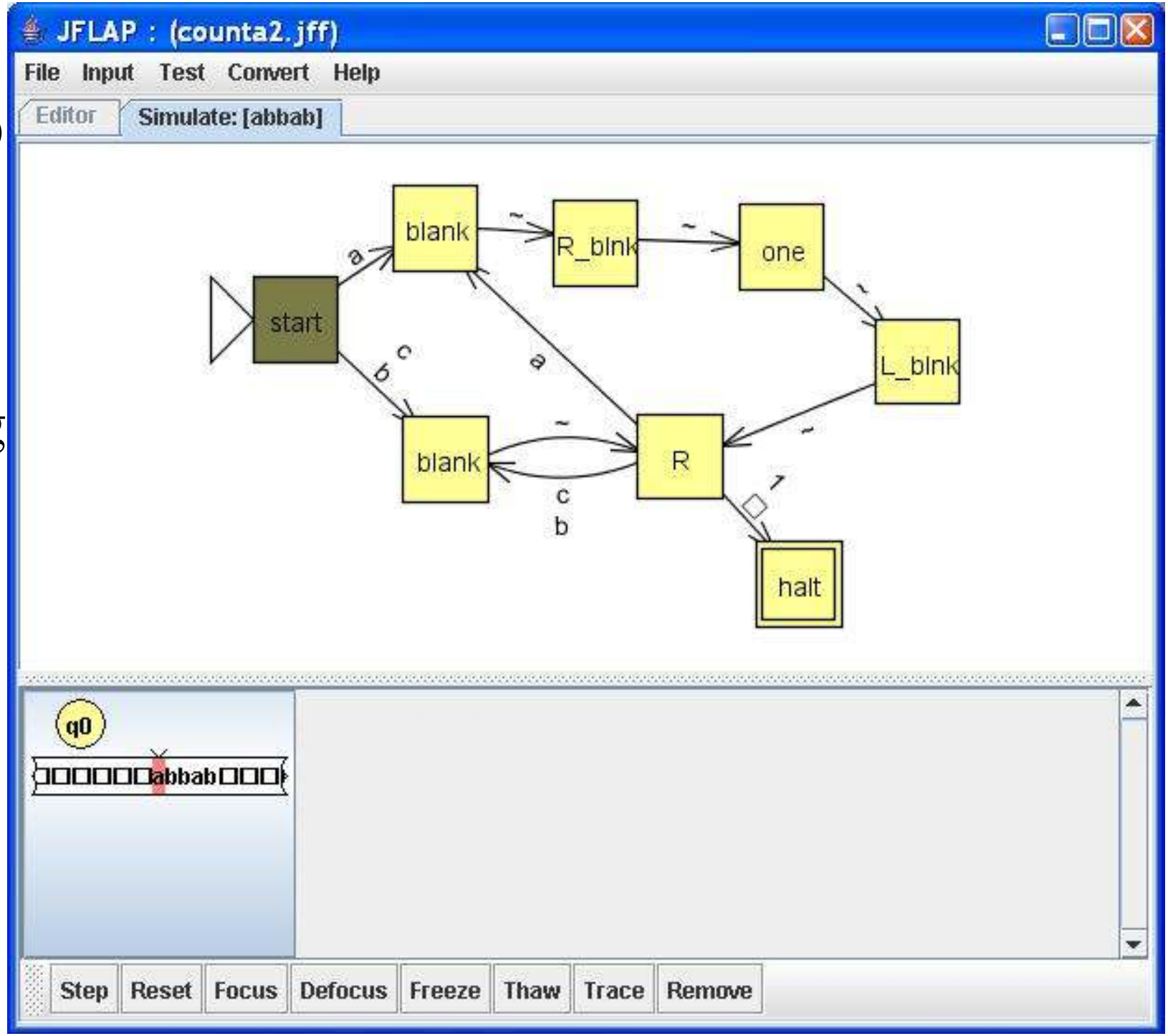


Building Block Run Choices

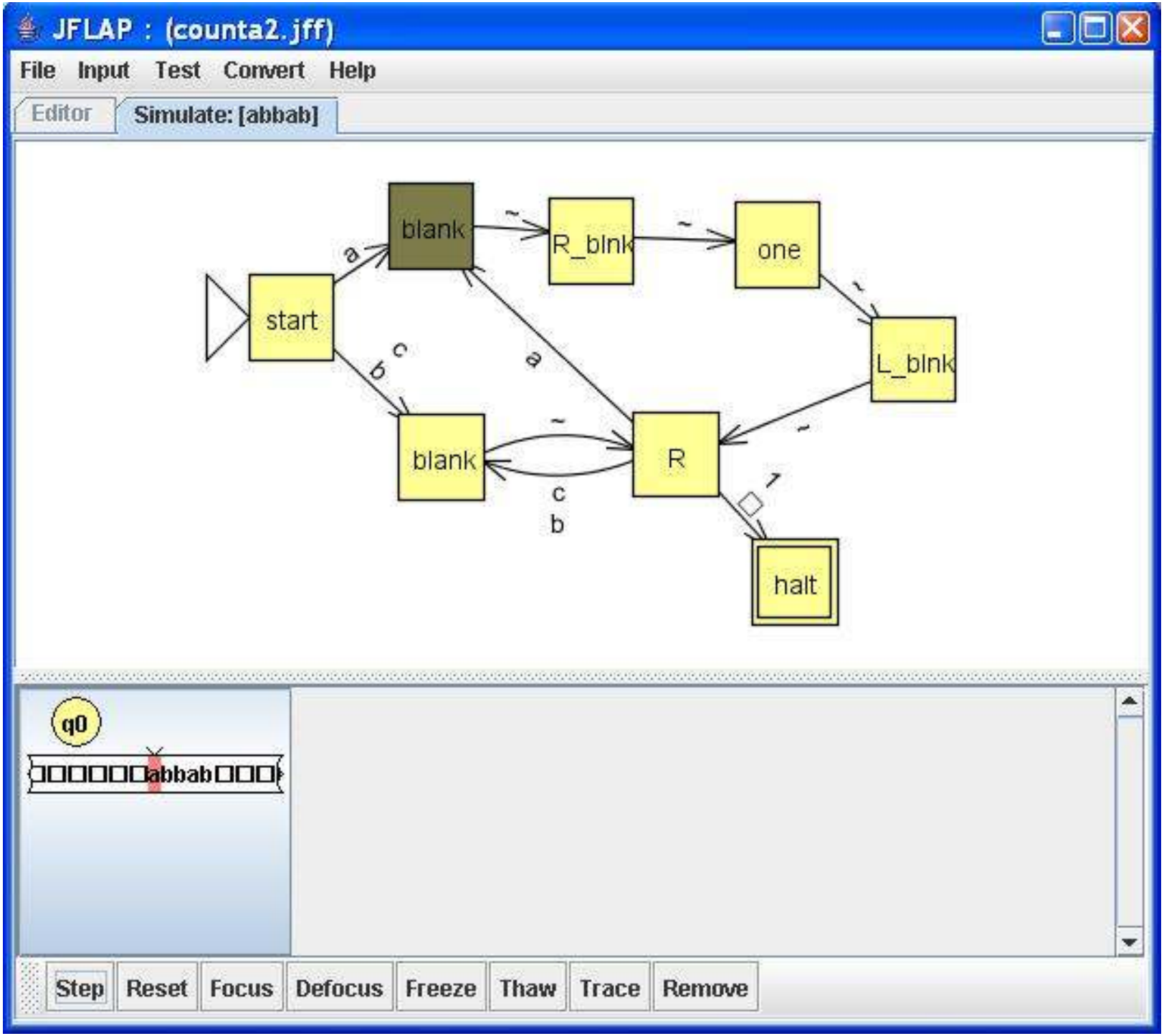


abbab

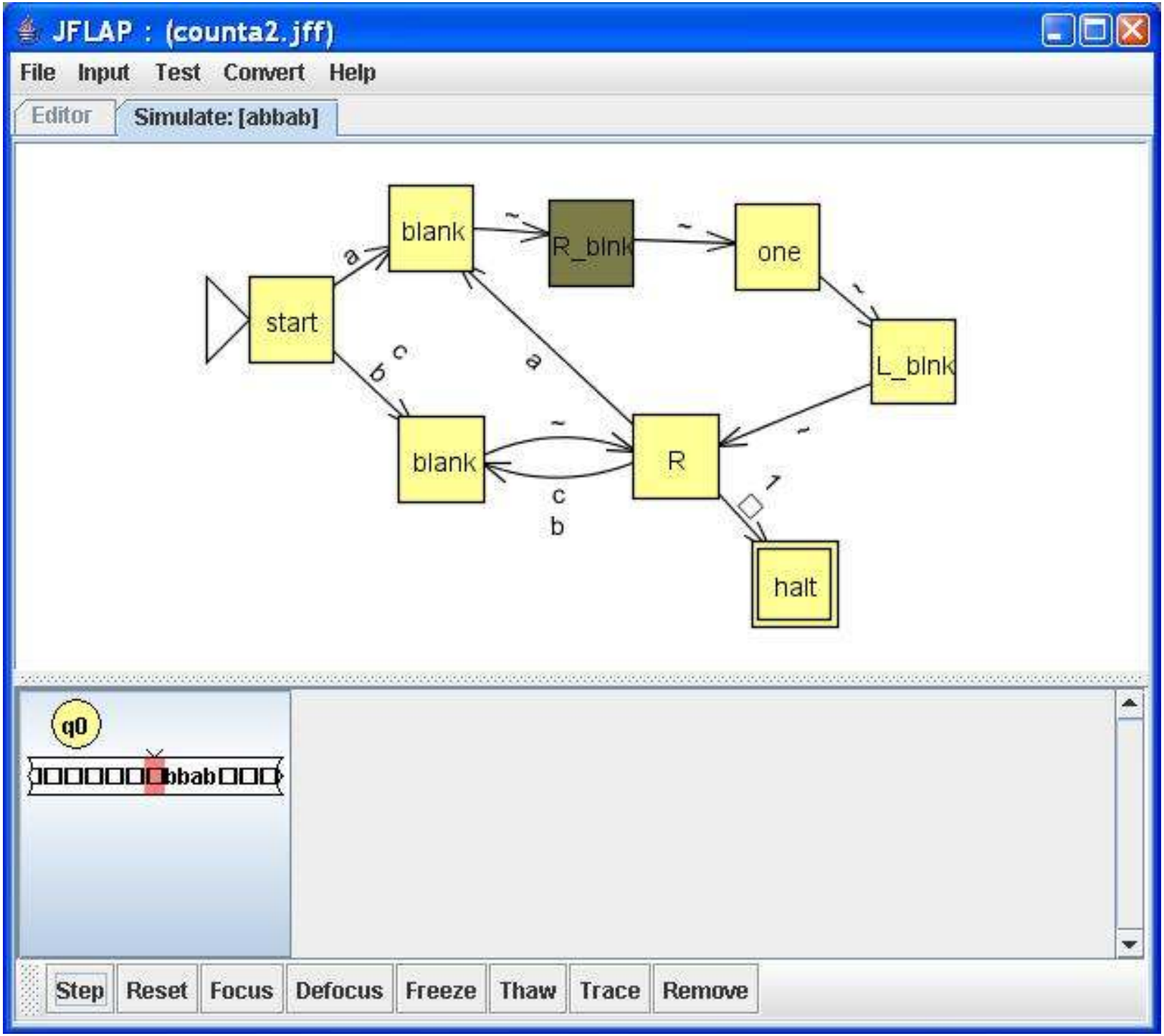
Step by building block



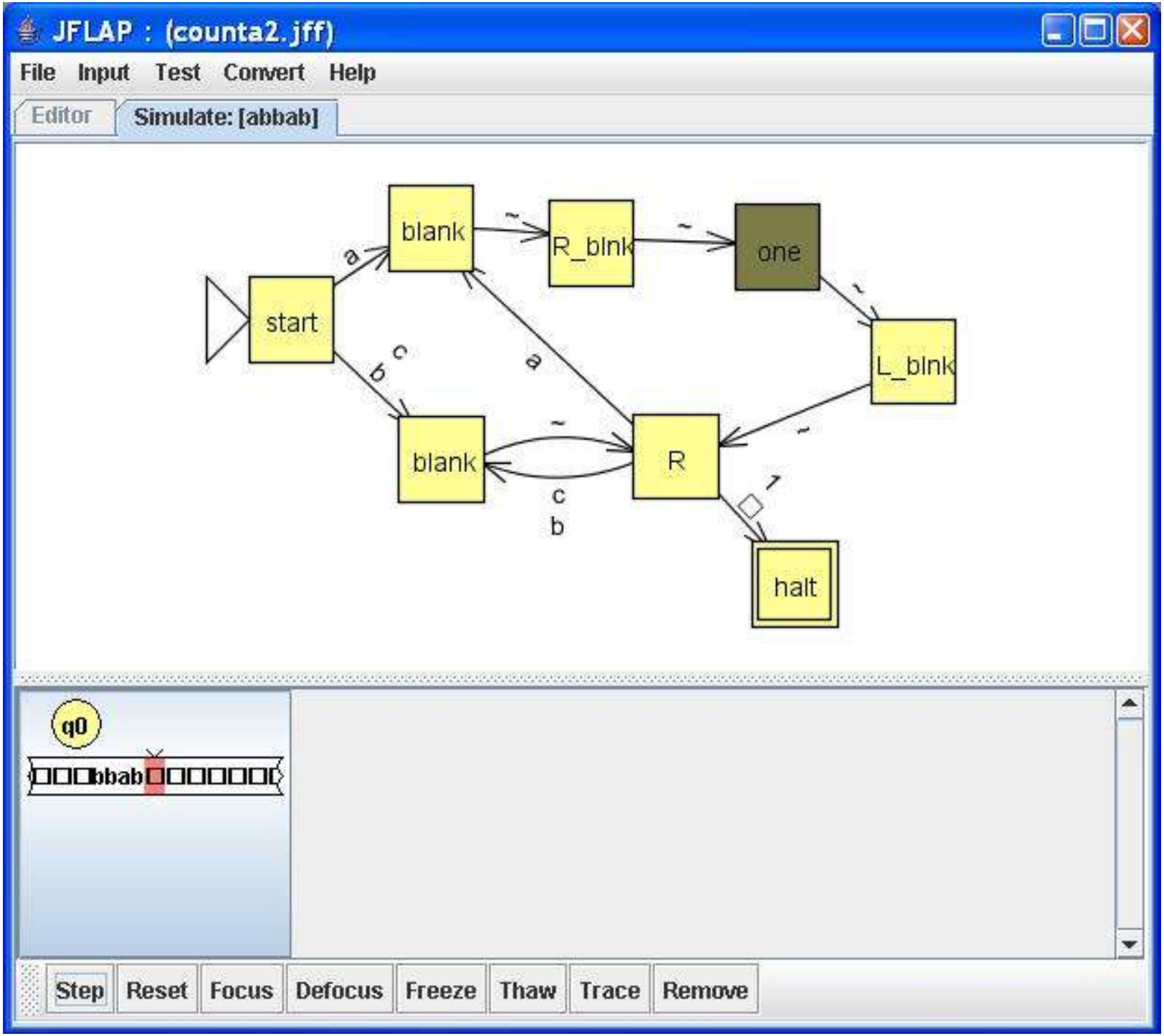
abbab


JFLAP : (counta2.jff)
File Input Test Convert Help
Editor
Simulate: [abbab]
start
blank
R_blnk
one
L_blnk
blank
R
halt
a
b
c
a
c
b
q0
abbab
Step Reset Focus Defocus Freeze Thaw Trace Remove

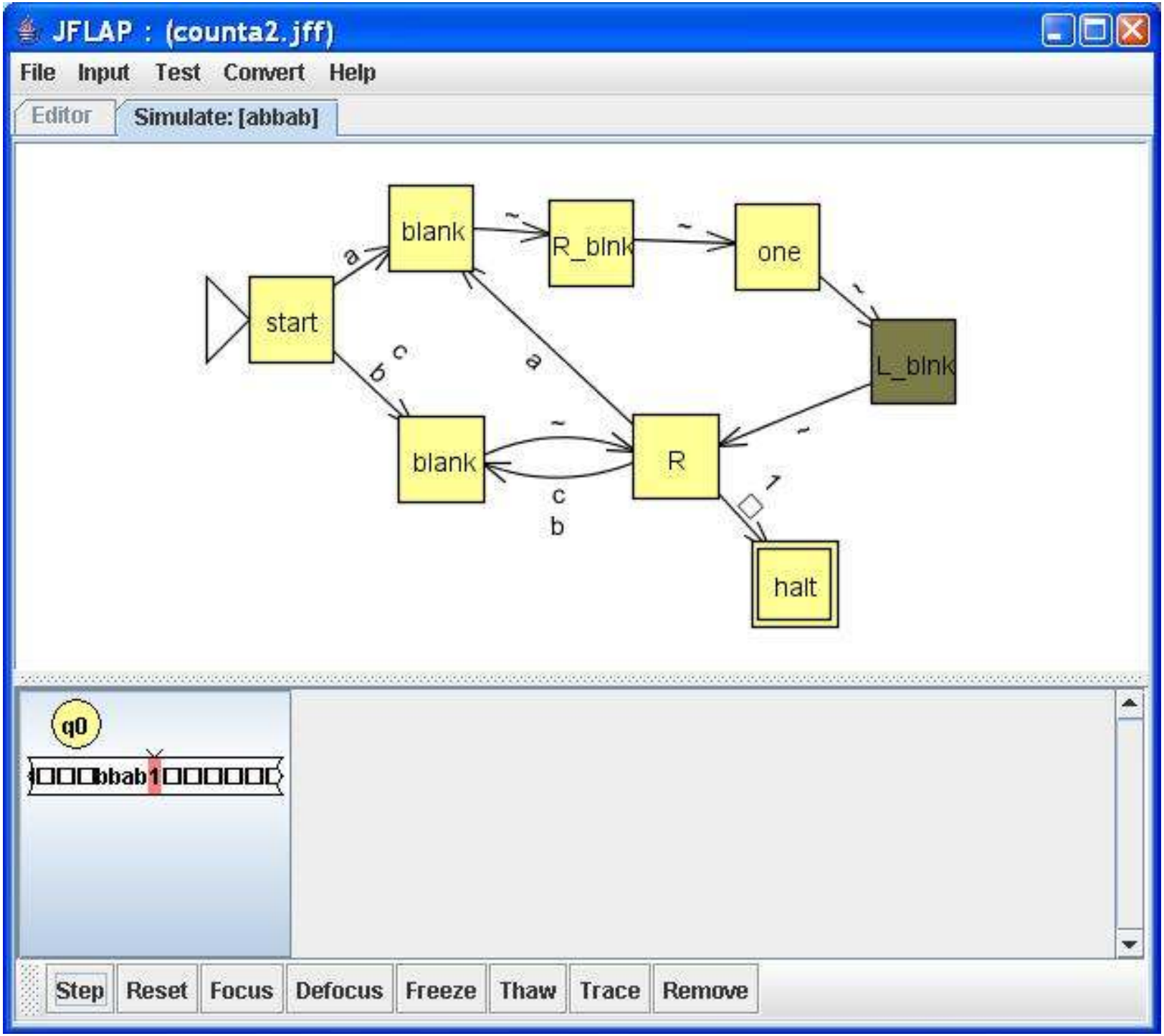
abbab


JFLAP : (counta2.jff)
File Input Test Convert Help
Editor
Simulate: [abbab]
start
blank
R_blnk
one
L_blnk
blank
R
halt
a
b
c
a
c
b
q0
abbab
Step Reset Focus Defocus Freeze Thaw Trace Remove

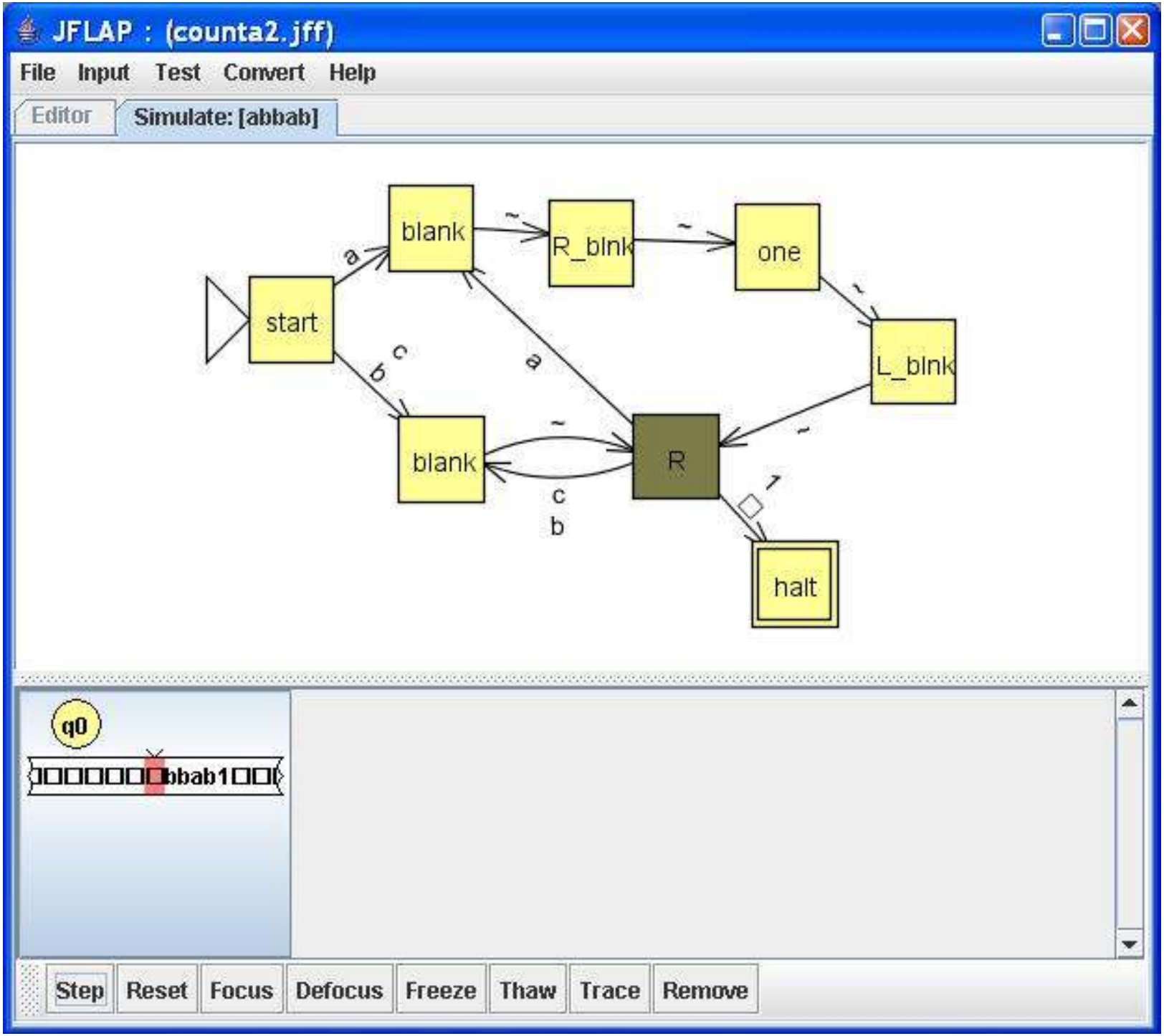
abbab


JFLAP : (counta2.jff)
File Input Test Convert Help
Editor
Simulate: [abbab]
start
blank
R_blnk
one
L_blnk
blank
R
halt
a
b
c
a
c
b
q0
abbab
Step Reset Focus Defocus Freeze Thaw Trace Remove

abbab

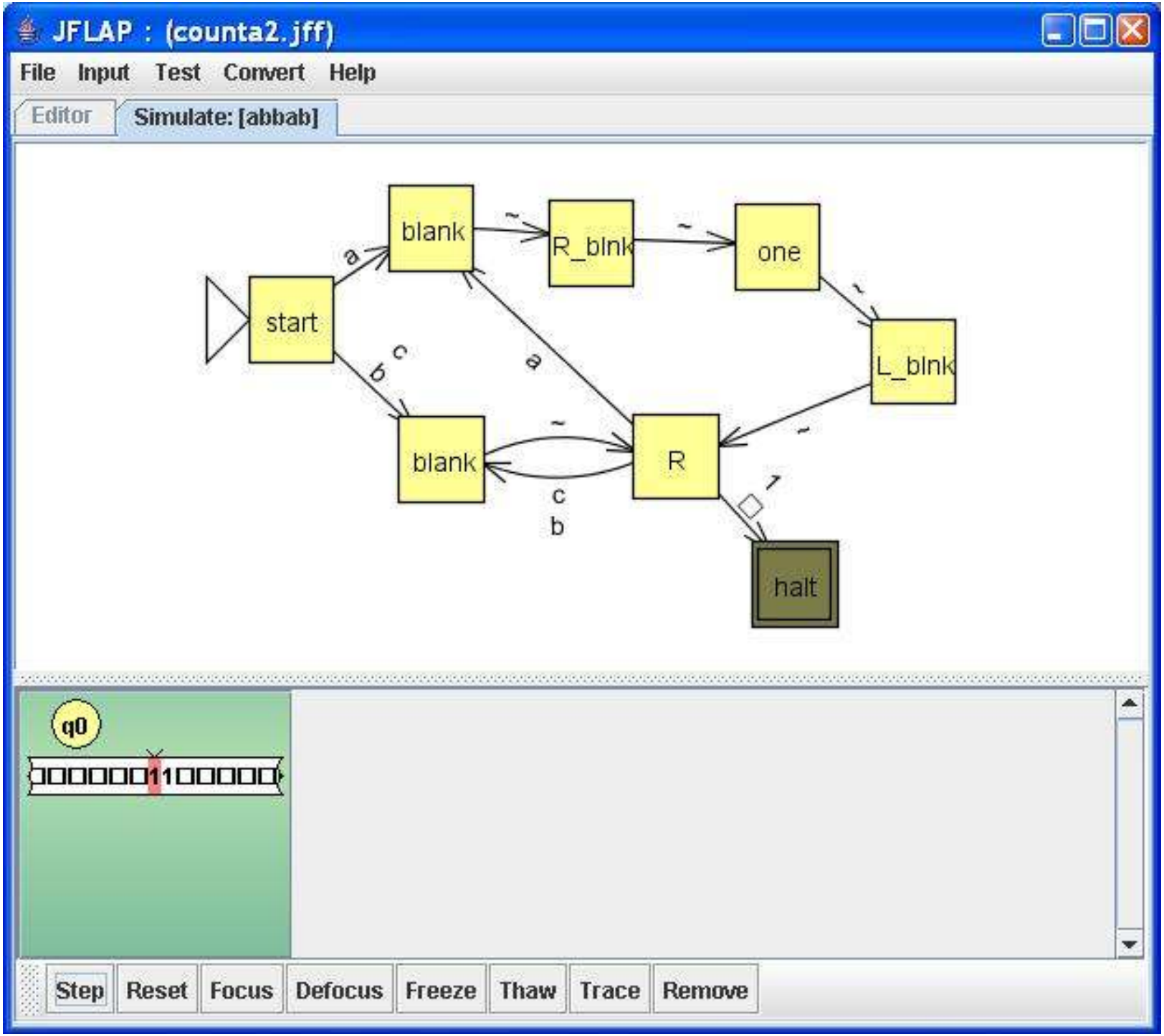

JFLAP : (counta2.jff)
File Input Test Convert Help
Editor
Simulate: [abbab]
start
blank
R_blnk
one
L_blnk
blank
R
halt
a
b
c
a
c
b
q0
bbab1
Step Reset Focus Defocus Freeze Thaw Trace Remove

abbab


JFLAP : (counta2.jff)
File Input Test Convert Help
Editor
Simulate: [abbab]
start
blank
R_blnk
one
L_blnk
blank
R
halt
a
b
c
a
c
b
q0
bbab1
Step Reset Focus Defocus Freeze Thaw Trace Remove

abbab

- Skip a few steps to …



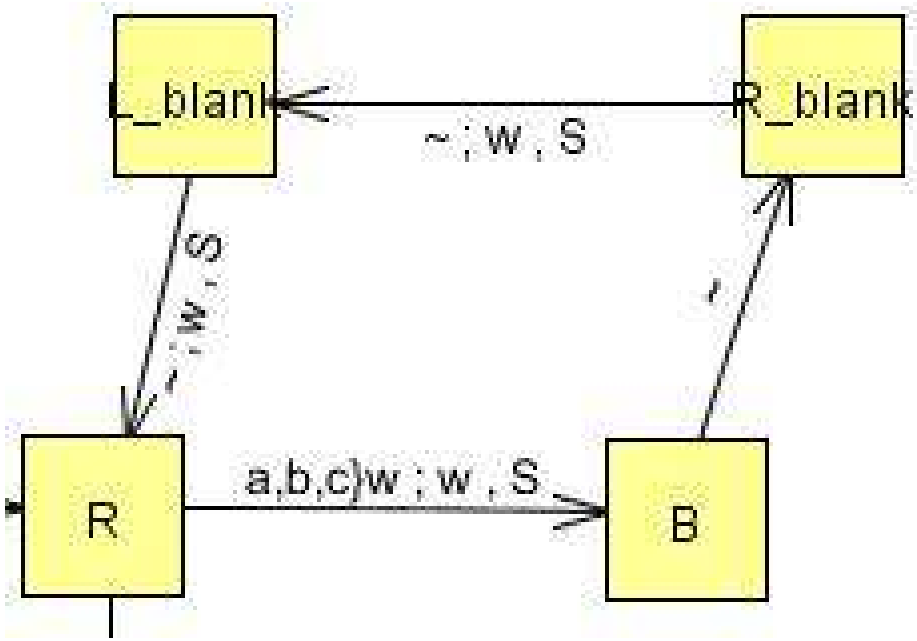
Combine Building Blocks w/ variables

- Variables in transitions

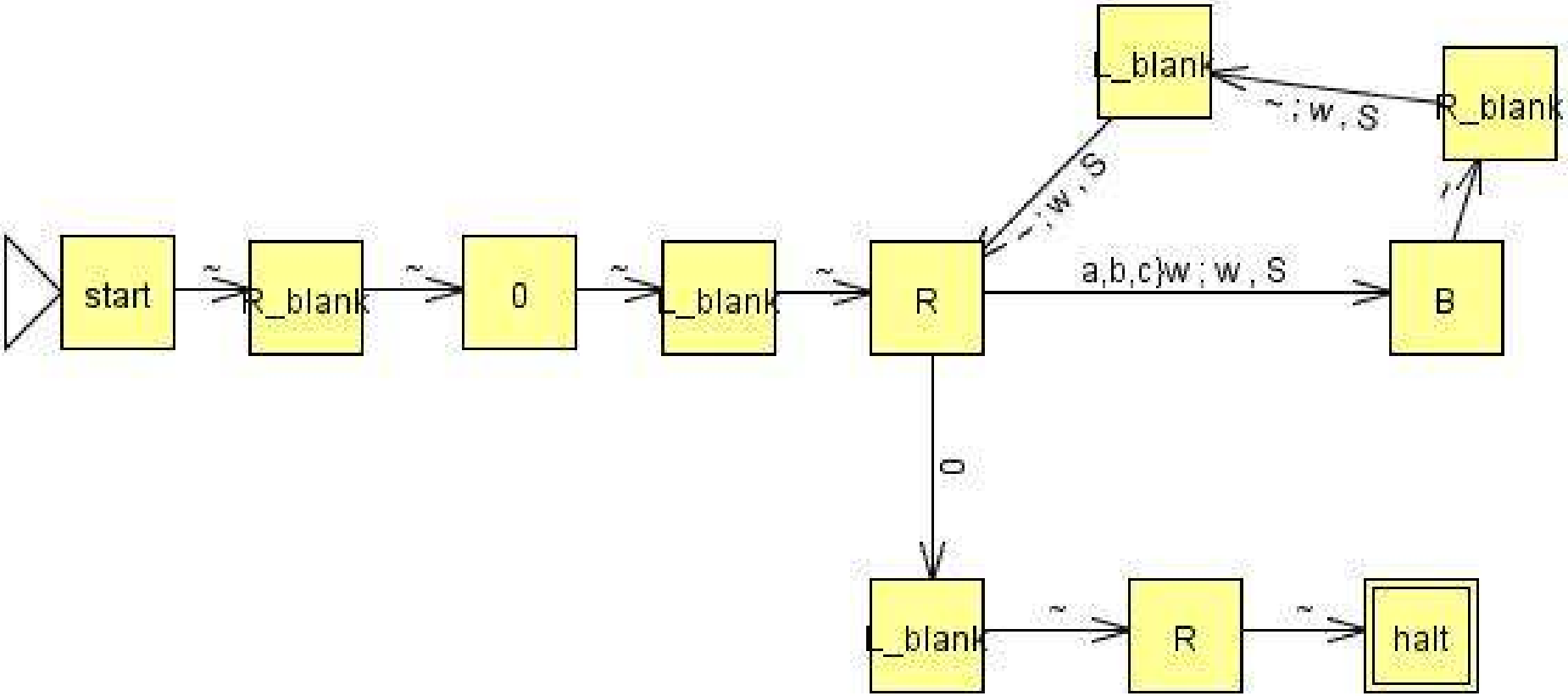
  If a_i is the current symbol, replace v with a_i each time v appears

  $a_1, a_2, a_3, \ldots a_n \} v$

- Example



Example: Copy f(w) = w0w



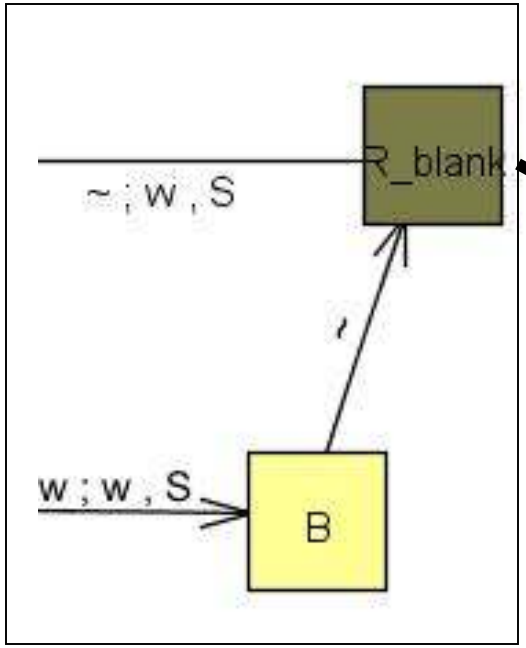
Run: Copy f(w) = w0w

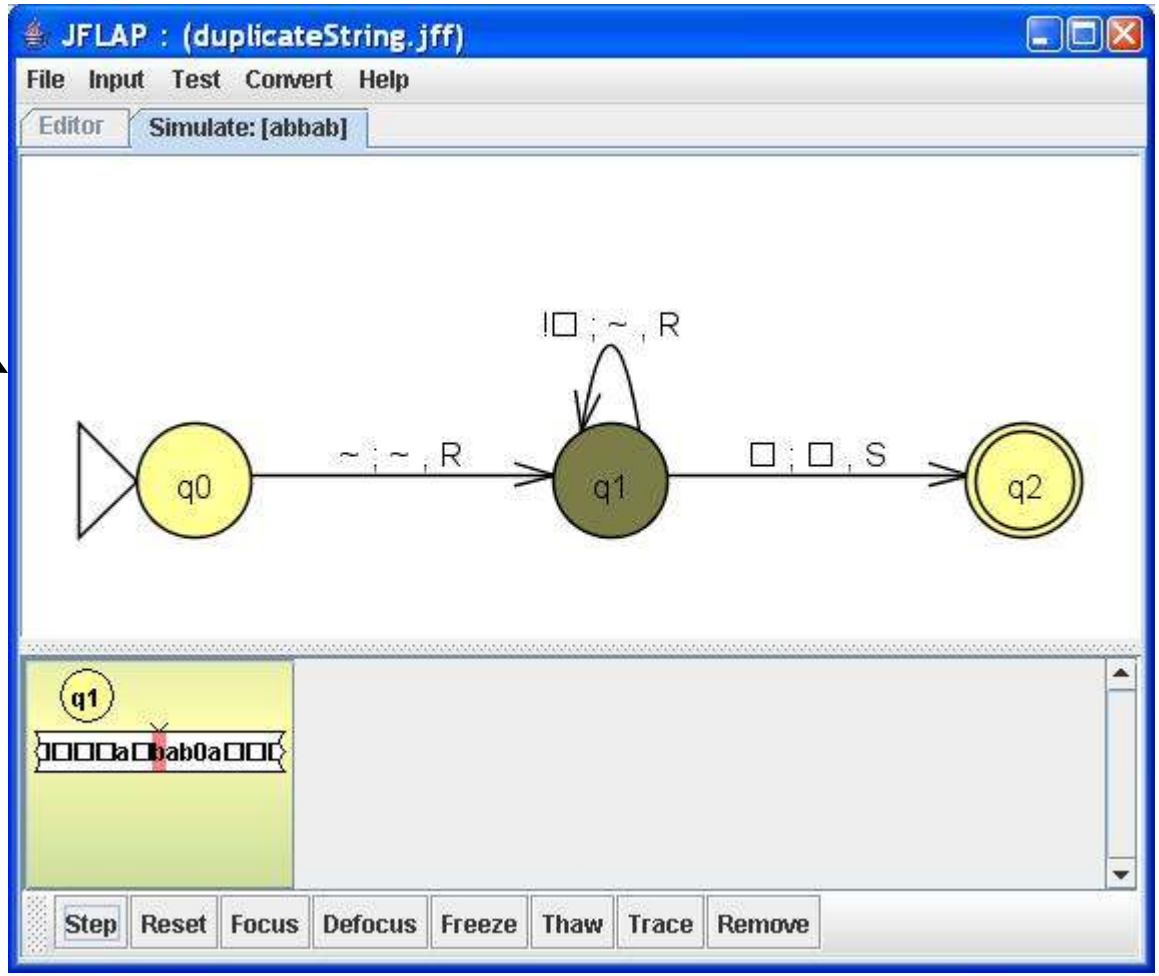
- Multiple Run (Transducer)

Input	Output	Result
a	a0a	Accept
ab	ab0ab	Accept
baa	baa0baa	Accept
bcab	bcab0bcab	Accept
cabbac	cabbac0cabbac	Accept

BB Step Run

- More detailed run, steps through each state inside building blocks



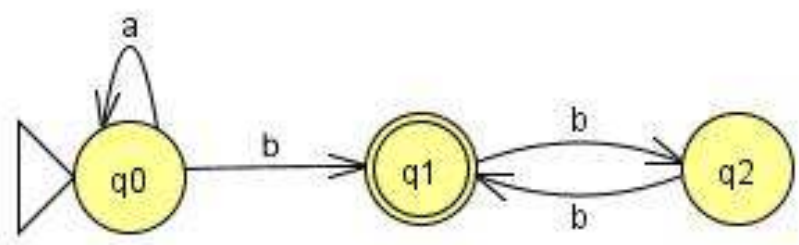


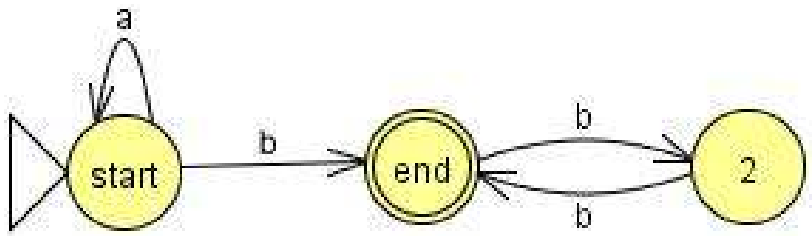
Building Blocks – what else?

- Edit a block – not advised
  - Best to test and debug, then import
- Name of block – default is file name
  - Can change name
- JFLAP files – XML format
  - BB – imports BB code into file
  - One copy of each BB based on name

Other New Additions to JFLAP

- Change the name of states

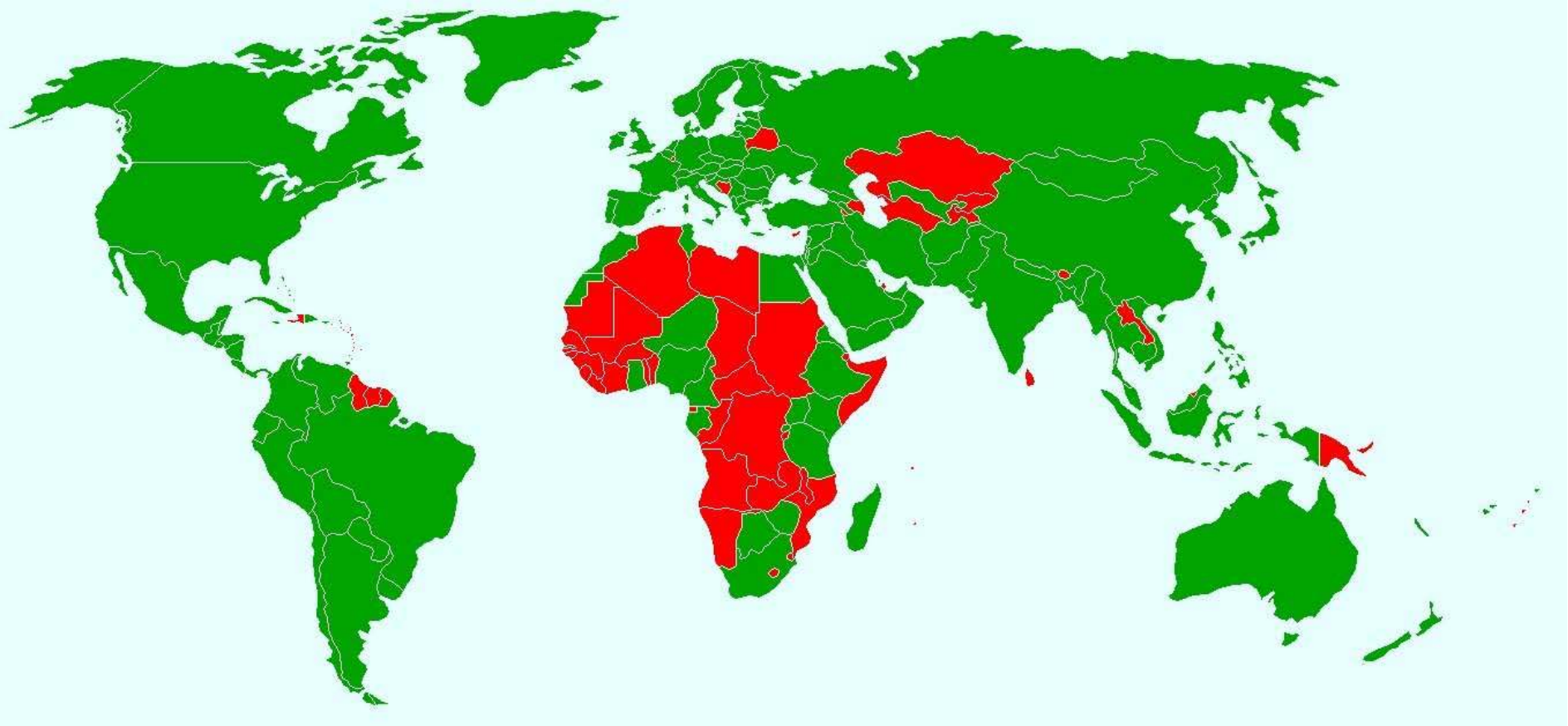




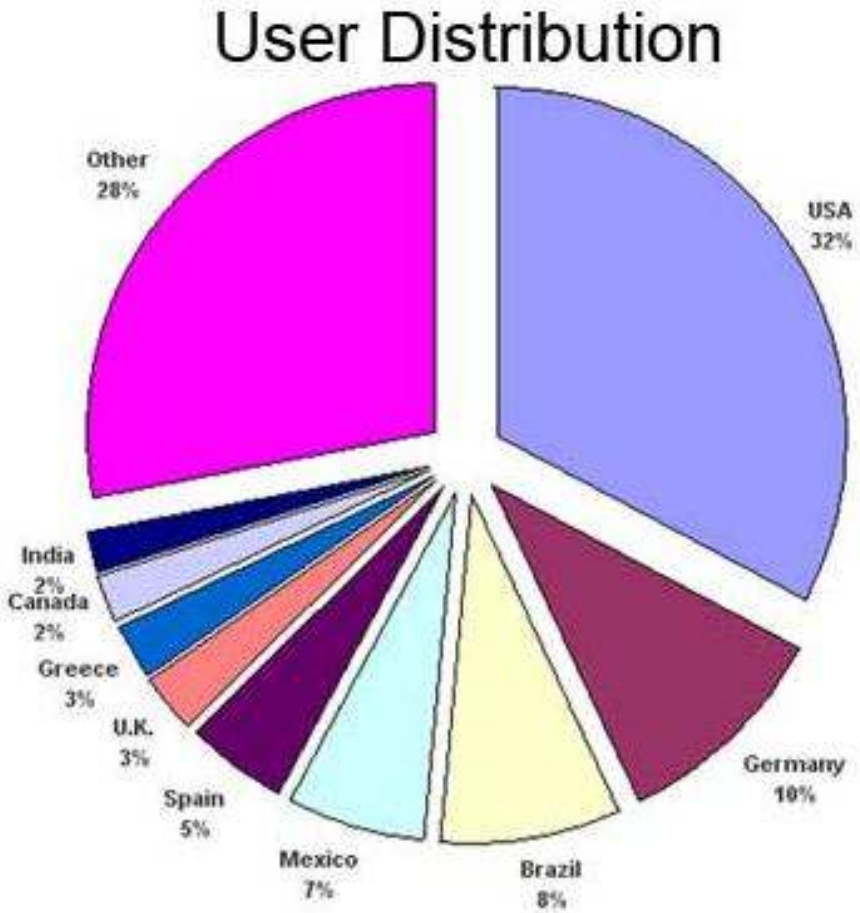
- Multiple Run transducer

JFLAP's Use Around the World

- Downloaded from 124 countries (green), over 25,000 downloads since Jan 2003



JFLAP's Use Around the World



Required?	
No	8999
Yes	8391
N/A	7931
Total:	25321

Reason For Usage	
Taking Course	11704
Teaching Course	3429
Research	1607
Other	1593
N/A	6988
Total:	25321

JFLAP's Use Around the World

- JFLAP web page has over 70,000 hits since 1996
- Google Search
  - JFLAP appears on over 14,000 web pages
  - Note: search only public web pages

JFLAP on web pages

- Course web pages

Computer Science 60
Principles of Computer Science
Spring 2005

CSE 354 Automata Theory and Formal Languages (Fall 2004)

03-60-214: Computer Languages, Grammars and Translators

(Winter 2006)

- Blogs

JFLAP. Discovered through Alex Nelson. An awesome learning tool for the creation and simulation of DFAs, NFAs, CFGs, Turing machines, and L-systems. This would have been so useful to discover last quarter.

JFLAP in German

Lernumgebung Automatentheorie mit JFLAP – Netscape

File Edit View Go Bookmarks Tools Window Help

Back Forward Reload Stop http://www.ifi.unizh.ch/cl/broder/jflap/ Search Print

Mail Home Radio Netscape Search Bookmarks Members WebMail Connections BizJournal SmartUpdate Mktplace

Um das JFLAP-Applet zu starten, hier klicken.

Theorie – Themen	Hilfe – Themen	Übungen
Theorie – Index	Hilfe – Index	Info – ?

Lernumgebung Automatentheorie mit JFLAP

Was ist JFLAP?
JFLAP ist ein an der Universität Duke (USA) entwickeltes interaktives Lernprogramm , welches die Automatentheorie mit praktischen Anwendungen ergänzt. JFLAP ermöglicht es dem Anwender, bestehende Beispiele durchzuspielen, sowie eigene Automaten zu konstruieren.

Was bietet diese Lernumgebung?
Wir haben JFLAP um zusätzliche Komponenten erweitert, welche zusammen eine einheitliche Lernumgebung bilden. Diese Lernumgebung besteht aus folgenden Komponenten:

Theorie eine Einführung in die Automatentheorie mit
- ***Themen*** (Schritt-für-Schritt)
- ***Index*** (Stichwortverzeichnis)

Hilfe eine Hilfedokumentation und Einführung in des Programm JFLAP mit
- ***Themen*** (Schritt-für-Schritt)
- ***Index*** (Stichwortverzeichnis)

Übungen Übungen zu den einzelnen Automatentypen und zu den JFLAP-Funktionen (mit Lösungen)

JFLAP–Applet das eigentliche Programm JFLAP zum graphischen Konstruieren und Testen von Automaten

Einsteigern wird dringend empfohlen, zuerst die Help-Themen anzuschauen, bevor erste Schritte mit JFLAP unternommen werden!

Info (diese) Informationen für den Benutzer

JFLAP in Spanish

Ingeniería Técnica de Informática de Gestión / Sistemas

Asignatura *Bases de lenguajes de programación*
Curso 2002/03
Práctica opcional nº 1: Introducción a la herramienta *JFLAP*

Objetivo

El objetivo de la práctica es que el alumno se familiarice con la herramienta **JFLAP**, orientada a la práctica visual e interactiva de los conceptos sobre lenguajes formales y teoría de autómatas. Mediante el uso de esta herramienta se practicarán operaciones relacionadas con gramáticas regulares, autómatas finitos y obtención del árbol de derivación en gramáticas independientes del contexto.

Obligatoriedad
La práctica no es obligatoria.
Prerrequisitos

El alumno debe conocer los elementos relacionados con los niveles 2 y 3 de la *jerarquía de Chomsky* (lenguajes regulares, expresiones regulares, gramáticas regulares, autómatas finitos, lenguajes y gramáticas independientes del contexto.
Es recomendable un conocimiento elemental de manejo del sistema operativo Windows.
Descripción

A continuación se enuncian diferentes operaciones para experimentar con la herramienta **JFLAP**.

JFLAP in Swedish

JFLAP 3.0

Eftersom konstruktionen av automater i JFLAP utgår från en grafisk representation som användaren ritar och inte från reguljära uttryck (eller, för den delen, andra formella språk som hanteras av av JFLAP), så finns/behövs det inga mekanismer för att expicit manipulera finita maskiner. På det sättet är JFLAP annorlunda än de andra systemen beskrivna i den här rapporten. Jämförelsen mellan JFLAP och XFST enligt de punkter som finns i avsnitt 3.1 ser ut som följer;

1. JFLAP är avsett för utbildning och går antagligen inte att använda för utveckling av större system.
2. Det går att spara automater i textformat på disk för att senare läsa in dem i JFLAP igen.
3. Eftersom JFLAP inte kan användas på ett sätt som kräver att det ska vara effektivt så kan man anta att det inte är det (det finns inget i den medföljande dokumentationen som pekar åt det ena eller det andra hållet).
4. Abstraktionsnivån i gränssnittet är visserligen hög (automaterna uttrycks som transitionsdiagram och högre än så kan väl knappast abstraktionsnivån bli i sammanhanget?), men eftersom funktionaliteten inte är speciellt utbyggd och syftet med verktyget ganska långt från vad XFST klarar av, så har abstraktionsnivån ingen betydelse.
5. JFLAPs gränssnitt kan manipuleras på ett relativt deklarativt sätt.

JFLAP in Chinese

JFLAP DEMO APPLET

斐森枑鼎湮模珨跺倛宒逄晟睿赻雄儂腔JAVA落翑諒悝馱撿亡﹟筽※衄嫛赻雄儂§粕等蔚﹟斕扢數斕赻撩腔赻雄儂甜珨彤赻雄儂腔硒俴﹟錶˙※淏寞桶湛宒§粕等蔚堆翑斕妗郈淏寞桶湛宒砃祥﹟隅腔衄嫛赻雄儂腔蛌遙〕祥﹟隅腔衄嫛赻雄儂砃﹟隅腔衄嫛赻雄儂腔蛌遙眕摯妗郈赻雄儂腔袨慨鄭苤趙〔

JFLAP 堆翑

掛JAVA Applets剒猁IE4.0麼Netscape4.5眕奻唳掛腔銡擬﹟腔盓厥亡樓婥Applets剒猁珨隅腔奀潔亡﹟騵陑脹渾〔

JFLAP Study

- Study of JFLAP's effectiveness in learning
  - Runs 2005-2007
  - Pretest/Posttest
  - Interviews
- Supported by National Science Foundation, grant NSF DUE 0442513

Twelve Participants

- Duke
- UNC-Chapel Hill
- Emory
- Winston-Salem State University
- United States Naval Academy
- Rensselaer Polytechnic Institute
- UC Davis
- Virginia State University
- Norfolk State University
- University of Houston
- Fayetteville State University
- University of Richmond

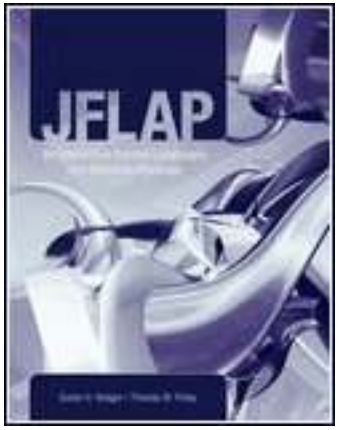
Looking for a few more for 2006-07

Contact me

More on JFLAP

- **www.jflap.org**

- JFLAP book (Jones & Bartlett, 2006)
  - Use as supplement to a textbook



- JFLAP Workshop Saturday at SIGCSE

Questions?