Program Synthesis

formula

grammar

Question: Does there exist a function expression $f \in G$

s.t. $\forall$ inputs $\vec{x}$, $\varphi(f, \vec{x})$ holds?

φ: Quantifier-free F.O. formula

Start ::= x | y | 0 | 1

Terminal symbols

Nonterminal symbols

| Start + Start

Start − Start → Production rule

| if StartBool then Start else Start

StartBool ::= Start ≤ Start

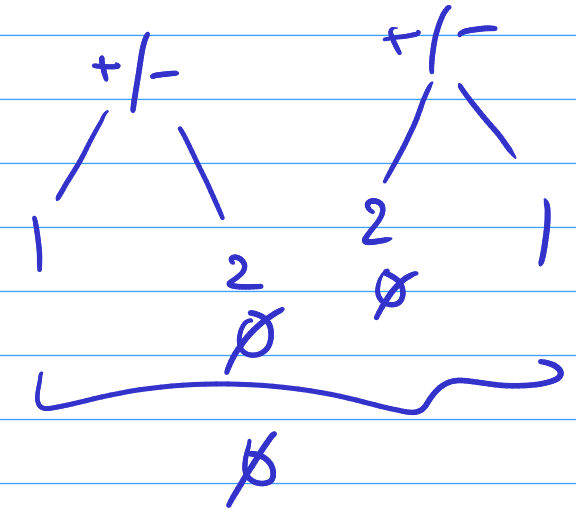
| StartBool and StartBool

| not StartBool

start

1 2 3 4

x	∅	+xx	+yx	+0x	+1x
y		+xy	+yy	+0y	+1y
0		+x0	+y0	+00	+10
1		+x1	+y1	+01	+11



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. . .

Production
Expression

$$f(x, y) = \text{if } x \leq x+y \text{ then } x \text{ else } 0-x$$

The Synthesis Problem

Does $\exists f \in G \quad \forall \vec{x} \quad \varphi(f\,\vec{x})$ holds?

Simpler Problem

I give you a candidate f.

Is it the case that

$$\forall \vec{x} \quad \varphi(f\,\vec{x}) \text{ holds?}$$

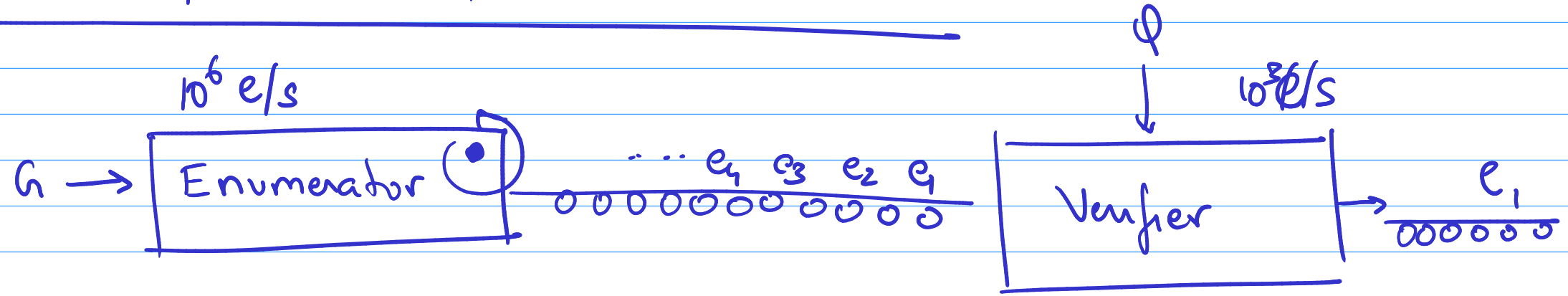
$$\neg(\exists \vec{x} \quad \neg\varphi(f\,\vec{x})?)$$

Essentially, can you give us a counterexample $\vec{x}$ s.t.

$$\neg \varphi(f \ \vec{x}) \ ?$$

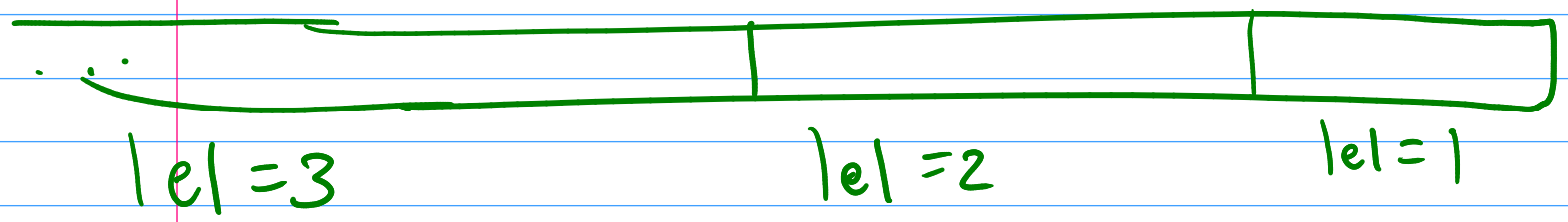
where f does not work?

The Sygus Factory Version 0



Enumerate expressions in order of increasing size.

$\exists \vec{x} \cdot \neg \varphi(f, \vec{x})$?



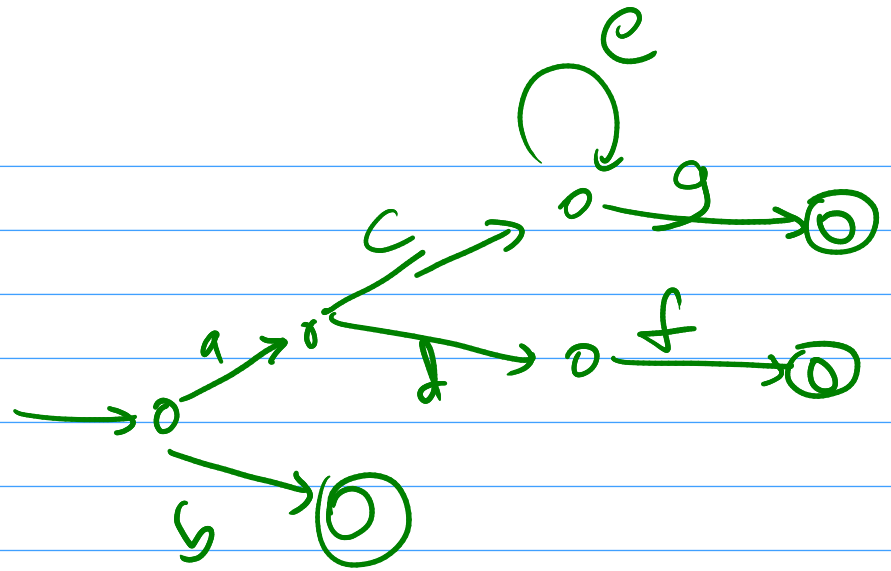
Simple Counting: 0 1 2 3 4 . . . -

Bad Counting: All even #s first, all odd #s after

0 2 4 6 8 . . . . ∞ !

Not so bad counting: 3 2 1 0 7 6 5 4 11 10 9 8

. . .


c
g
c
a
f
d
b

Analyzing Sylus Factory V0

Enumerator : 10^6 e/s

Verifier : 10^3 e/s

Time to get to e # 10^6 = 1001 seconds.

SyhuS Factory V 0.9

φ : $\forall x \; y \quad f(x,y) \geq x \quad f(x\ y) \geq y$

Is it the case that

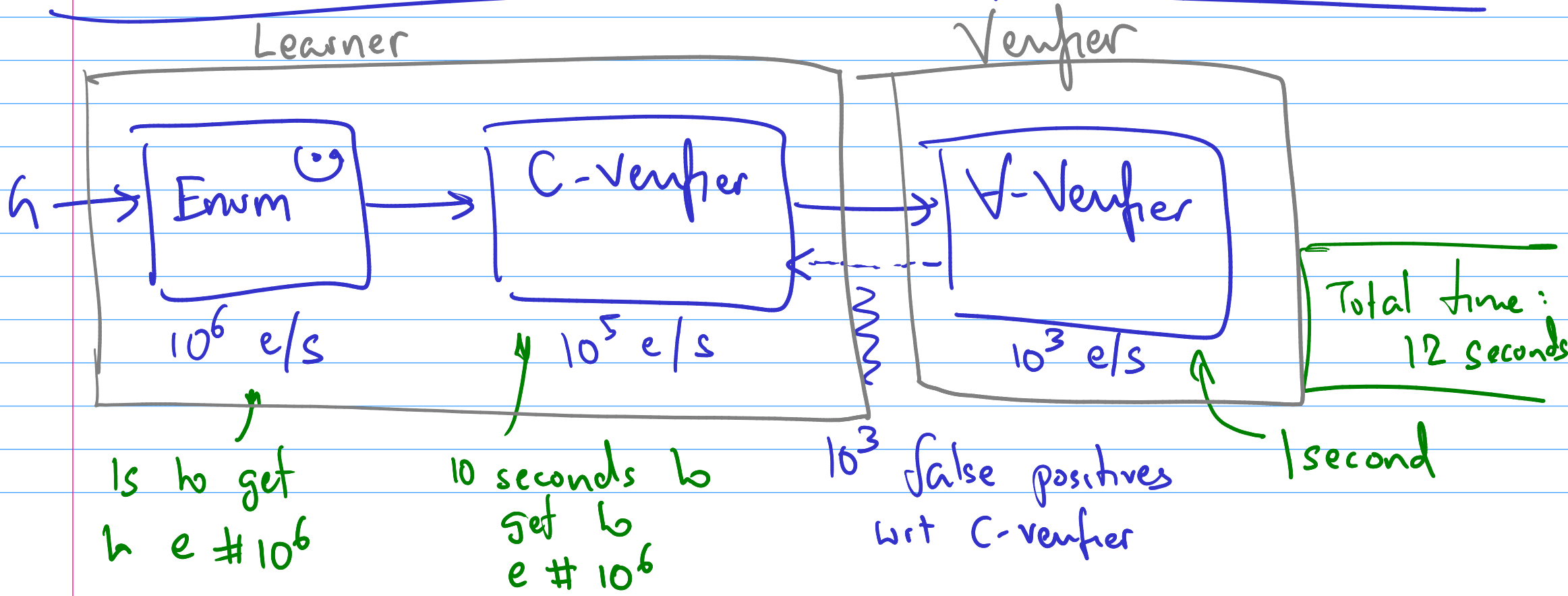
$f(3\ \ 2) \geq 3$

$f(3\ \ 2) \geq 2$

Assuming half of all expressions pass the C-verifier so to get to $c \# 10^6$.

Sylis Factory Version 1.0 CEGIS

Counter-example Guided Inductive Synth



$\forall x\ y \in \mathrm{Int} \times \mathrm{Int},$ ——————

$\forall x\ y \in C \subseteq \mathrm{Int} \times \mathrm{Int},$ ——————