

第一步：找过程中一直在减小的量  
 $r = f(a)$

第二步： $I \equiv r = f(a)$  Loop Inva.

第三步： $F \equiv r > f(a)$  (顺理成章)

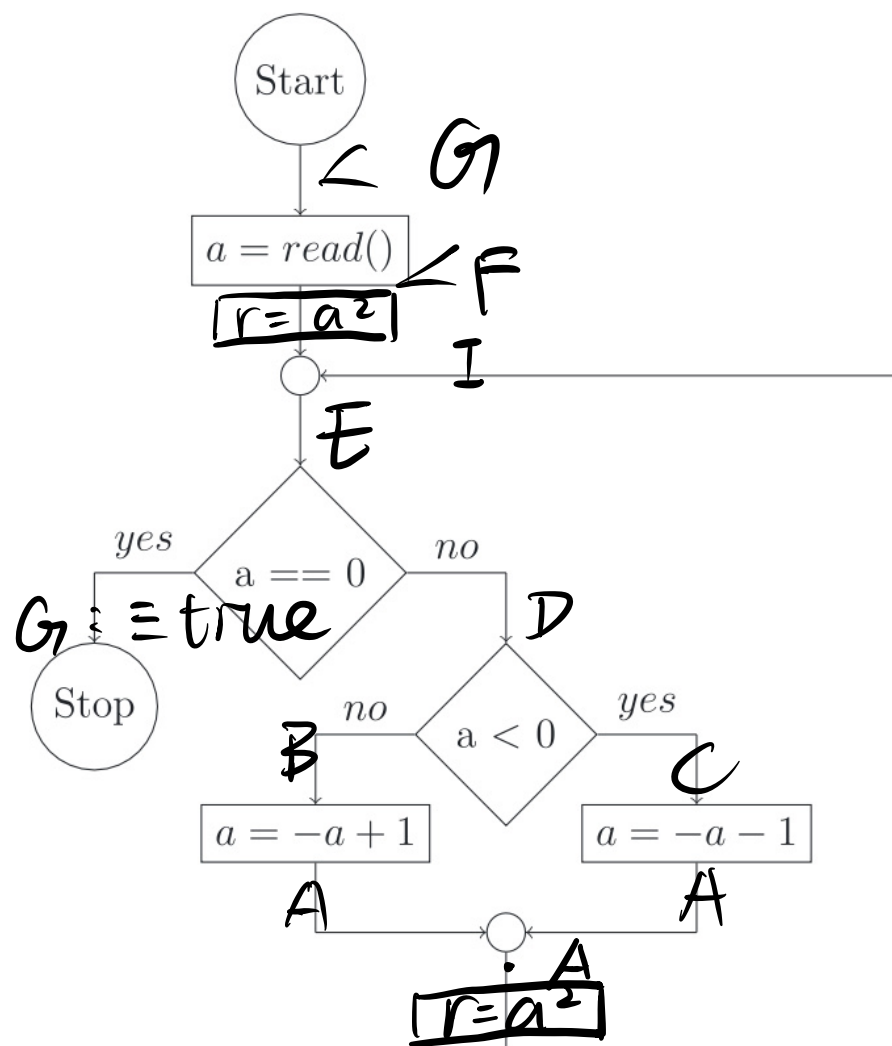
第四步：往前推理到S点

第五步：证 C点  $\Rightarrow r \geq 0$

证 F点  $\Rightarrow r > f(a)$

证 Inva 有效

练习:



$$\textcircled{1} \text{ I} \equiv r = a^2$$

$$\textcircled{2} \text{ WP I } r = a^2 \text{ I } (I)$$

$$\equiv \text{ I I } (a^2/r) \equiv a^2 = a^2$$

$$\equiv \text{ true} \Leftarrow \underbrace{r > a^2} \equiv A$$

$$\textcircled{3} \text{ WP I } a = -a + 1 \text{ I } (A)$$

$$\equiv \text{ I A I } (1 - a/a)$$

$$\equiv r > (1 - a)^2 \equiv B$$

$$\textcircled{4} \text{ WP I } a = -a - 1 \text{ I } (A)$$

$$\equiv \text{ I A I } (-a - 1/a)$$

$$\equiv r > (-a - 1)^2 \equiv C$$

$$\textcircled{5} \text{ WP I } a < 0 \text{ I } (B, C)$$

$$\equiv (a \geq 0 \wedge B) \vee (a < 0 \wedge C)$$

$$\equiv (a \geq 0 \wedge r > (-a)^2) \vee (a < 0 \wedge r > (a+1)^2)$$

$r > (1-|a|)^2$   
 $r \neq 0$

$r \neq 0$

⑥  $WP \models a = 0 \models (D, G)$

$$\equiv (a \neq 0 \wedge D) \vee (a = 0 \wedge G)$$

$$\equiv (a \neq 0 \wedge r > a^2 - 2|a| + 1) \vee (a = 0)$$

$\uparrow$   
 $I \equiv r = a^2$

方1°  
 $I \rightarrow$  这个

方2°

方2°  $a \Rightarrow b$  为真  
 $\neg a \vee b$  为真

$$\neg (a \neq 0 \wedge r > a^2 - 2|a| + 1) \wedge \neg (a \neq 0)$$

$$= (a = 0 \vee r \leq a^2 - 2|a| + 1) \wedge (a = 0)$$

$$= a = 0$$

$$\Rightarrow r \neq a^2 \quad (\mathbb{R} \setminus \mathbb{B})$$



$$\textcircled{1} \text{ WPI } r = a^2 \mid (I)$$

$$\equiv \neg I(I(a^2 / v))$$

$$\equiv a^2 = a^2 \equiv \text{true}$$

$$\therefore \equiv F$$

$$\textcircled{2} \text{ WPI } a = \text{read} \mid (F)$$

$$\equiv \text{true} \therefore \equiv G$$

$$\text{证 } r = a^2 \Rightarrow$$

$$(a \neq 0 \wedge v > a^2 - 2|a| + 1) \vee (a = 0)$$

枚举因为a为整数

$$a = 2 \quad v = 4$$

$$a = -1 \quad v = 1$$

$$a = 0 \quad v = 0$$

$$a = 1 \quad v = 1$$