
MODULE *pluscal_cubic*

EXTENDS *Integers, TLC*
 CONSTANTS *x* *x* is the input

-wfNext

```
--algorithm cube {
variables z = 0, v = 0, w = 1, t = 3, u = 0;
{
l0: skip;
w: while ( u < x ) {
  l1:
    z := z + v + w;
  l3:
    v := v + t;
  l4:
    t := t + 6;
  l5:
    w := w + 3;
  l6:
    u := u + 1;
  l7: skip;
} ;
l2: print ⟨z⟩;
}
}
```

BEGIN TRANSLATION

Label *w* at line 12 col 3 changed to *w_*

VARIABLES *z*, *v*, *w*, *t*, *u*, *pc*

vars \triangleq ⟨*z*, *v*, *w*, *t*, *u*, *pc*⟩

Init \triangleq Global variables

$\wedge z = 0$
 $\wedge v = 0$
 $\wedge w = 1$
 $\wedge t = 3$
 $\wedge u = 0$
 $\wedge pc = \text{"l0"}$

l0 \triangleq $\wedge pc = \text{"l0"}$
 $\wedge \text{TRUE}$
 $\wedge pc' = \text{"w_"}$
 $\wedge \text{UNCHANGED } \langle z, v, w, t, u \rangle$

$$\begin{aligned}
w_- &\triangleq \wedge pc = \text{"w_"} \\
&\quad \wedge \text{IF } u < x \\
&\quad \quad \text{THEN } \wedge pc' = \text{"l1"} \\
&\quad \quad \text{ELSE } \wedge pc' = \text{"l2"} \\
&\quad \wedge \text{UNCHANGED } \langle z, v, w, t, u \rangle \\
l1 &\triangleq \wedge pc = \text{"l1"} \\
&\quad \wedge z' = z + v + w \\
&\quad \wedge pc' = \text{"l3"} \\
&\quad \wedge \text{UNCHANGED } \langle v, w, t, u \rangle \\
l3 &\triangleq \wedge pc = \text{"l3"} \\
&\quad \wedge v' = v + t \\
&\quad \wedge pc' = \text{"l4"} \\
&\quad \wedge \text{UNCHANGED } \langle z, w, t, u \rangle \\
l4 &\triangleq \wedge pc = \text{"l4"} \\
&\quad \wedge t' = t + 6 \\
&\quad \wedge pc' = \text{"l5"} \\
&\quad \wedge \text{UNCHANGED } \langle z, v, w, u \rangle \\
l5 &\triangleq \wedge pc = \text{"l5"} \\
&\quad \wedge w' = w + 3 \\
&\quad \wedge pc' = \text{"l6"} \\
&\quad \wedge \text{UNCHANGED } \langle z, v, t, u \rangle \\
l6 &\triangleq \wedge pc = \text{"l6"} \\
&\quad \wedge u' = u + 1 \\
&\quad \wedge pc' = \text{"l7"} \\
&\quad \wedge \text{UNCHANGED } \langle z, v, w, t \rangle \\
l7 &\triangleq \wedge pc = \text{"l7"} \\
&\quad \wedge \text{TRUE} \\
&\quad \wedge pc' = \text{"w_"} \\
&\quad \wedge \text{UNCHANGED } \langle z, v, w, t, u \rangle \\
l2 &\triangleq \wedge pc = \text{"l2"} \\
&\quad \wedge \text{PrintT}(\langle z \rangle) \\
&\quad \wedge pc' = \text{"Done"} \\
&\quad \wedge \text{UNCHANGED } \langle z, v, w, t, u \rangle \\
Next &\triangleq l0 \vee w_- \vee l1 \vee l3 \vee l4 \vee l5 \vee l6 \vee l7 \vee l2 \\
&\quad \vee \text{Disjunct to prevent deadlock on termination} \\
&\quad \quad (pc = \text{"Done"} \wedge \text{UNCHANGED } vars) \\
Spec &\triangleq Init \wedge \Box[Next]_{vars} \\
Termination &\triangleq \Diamond(pc = \text{"Done"})
\end{aligned}$$

END TRANSLATION

$$MAX \triangleq 32768 \quad 16 \text{ bits}$$

$$D \triangleq 0 \dots 32768$$

$$x < 32760$$

$$DD(X) \triangleq (X \# \text{defaultInitValue} \Rightarrow X \in D)$$

$$\text{Safety_absence} \triangleq DD(y1) \wedge DD(y2) \wedge DD(y3) \wedge DD(z)$$

$$\text{Safety_partialcorrectness} \triangleq pc = \text{"Done"} \Rightarrow z = x * x * x$$

$$Inv \triangleq$$

$$pc \in \{ \text{"l0"}, \text{"w"}, \text{"l1"}, \text{"l2"} \}$$

$$\Rightarrow$$

$$\wedge w = 3 * u + 1$$

$$\wedge v = 3 * u^2$$

$$\wedge z + v + w = (u + 1)^3$$

$$\wedge v + t = 3 * (u + 1)^2$$

$$I13 \triangleq$$

$$pc = \text{"l3"}$$

$$\Rightarrow$$

$$\wedge w = 3 * u + 1$$

$$\wedge v = 3 * u^2$$

$$\wedge z = (u + 1)^3$$

$$\wedge v + t = 3 * (u + 1)^2$$

$$I14 \triangleq$$

$$pc = \text{"l4"}$$

$$\Rightarrow$$

$$\wedge w = 3 * u + 1$$

$$\wedge v = 3 * (u + 1)^2$$

$$\wedge z = (u + 1)^3$$

$$\wedge v = 3 * (u + 1)^2$$

$$I15 \triangleq$$

$$pc = \text{"l5"}$$

$$\Rightarrow$$

$$\wedge w = 3 * u + 1$$

$$\wedge v = 3 * (u + 1)^2$$

$$\wedge z = (u + 1)^3$$

$$\wedge v = 3 * (u + 1)^2$$

$$I16 \triangleq$$

$$pc = \text{"l6"}$$

$$\begin{aligned}
&\Rightarrow \\
&\wedge w = 3 * (u + 1) + 1 \\
&\wedge v = 3 * (u + 1)^2 \\
&\wedge z = (u + 1)^3 \\
&\wedge v = 3 * (u + 1)^2
\end{aligned}$$

$$\begin{aligned}
I\!I7 &\triangleq \\
pc &= \text{"I7"} \\
&\Rightarrow \\
&\wedge w = 3 * u + 1 \\
&\wedge v = 3 * u^2 \\
&\wedge z + v + w = (u + 1)^3 \\
&\wedge v + t = 3 * (u + 1)^2 \\
&\wedge z = u^3
\end{aligned}$$

$$\begin{aligned}
test &\triangleq \textit{Safety_partialcorrectness} \\
\textit{Safety1} &\triangleq Inv \wedge I\!I4 \wedge I\!I5 \wedge I\!I6 \wedge I\!I7 \\
\textit{Safety} &\triangleq Inv \wedge I\!I3 \wedge I\!I4 \wedge I\!I5 \wedge I\!I6 \wedge I\!I7
\end{aligned}$$
