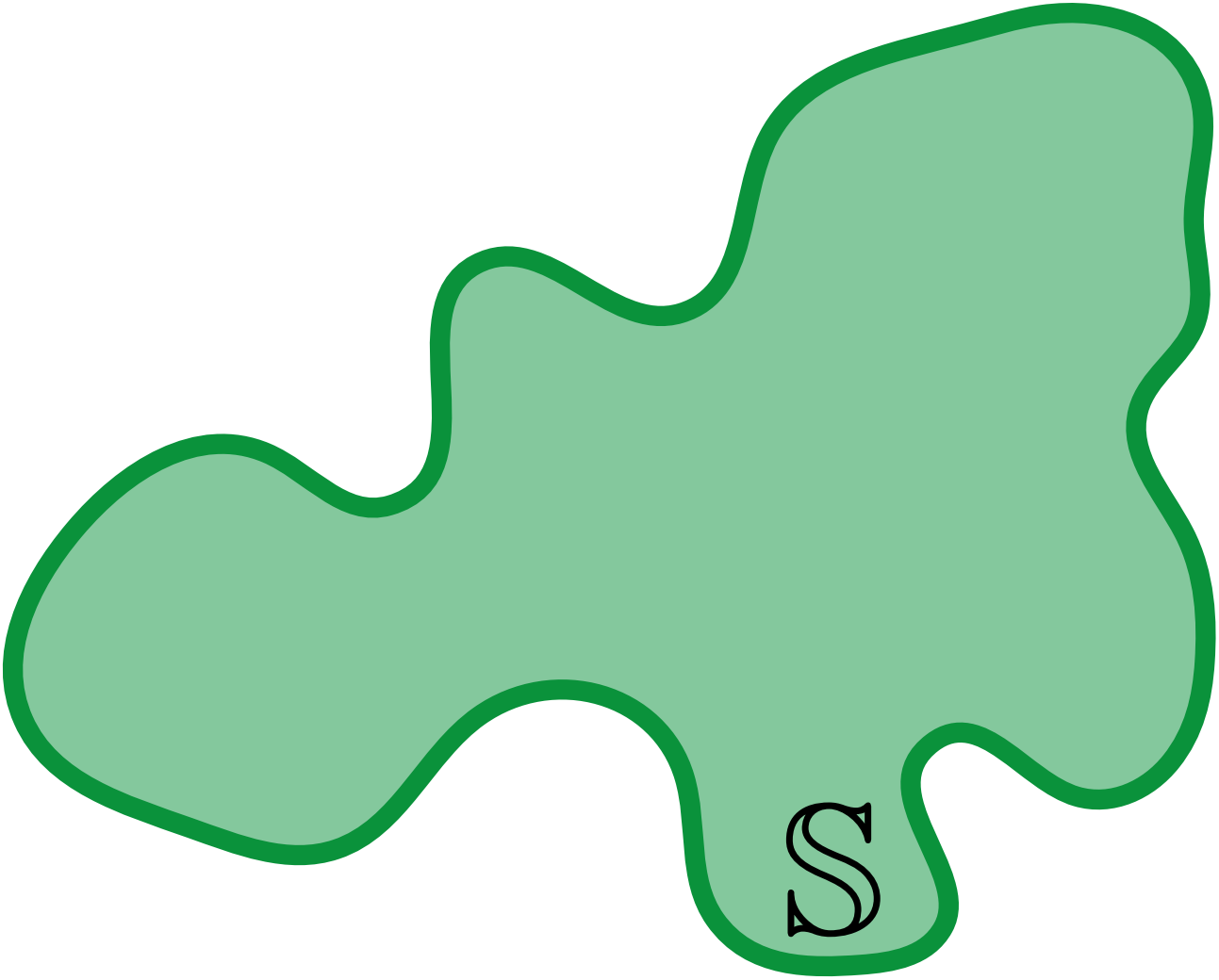
A


S


{ Head:∅ }


{ Head:∅, head:∅ }


{ Head:∅, head:ℙ }


{ Head:∅, head:ℙ }


{ Head:𝔸, head:ℙ }

$\{\ \mathtt{Head}\colon \mathbb{P} \wedge \mathbb{A},\ \mathtt{head}\colon \mathbb{P} \wedge \mathbb{A}\ \}$


{ Head:𝕊, head:𝕊 }

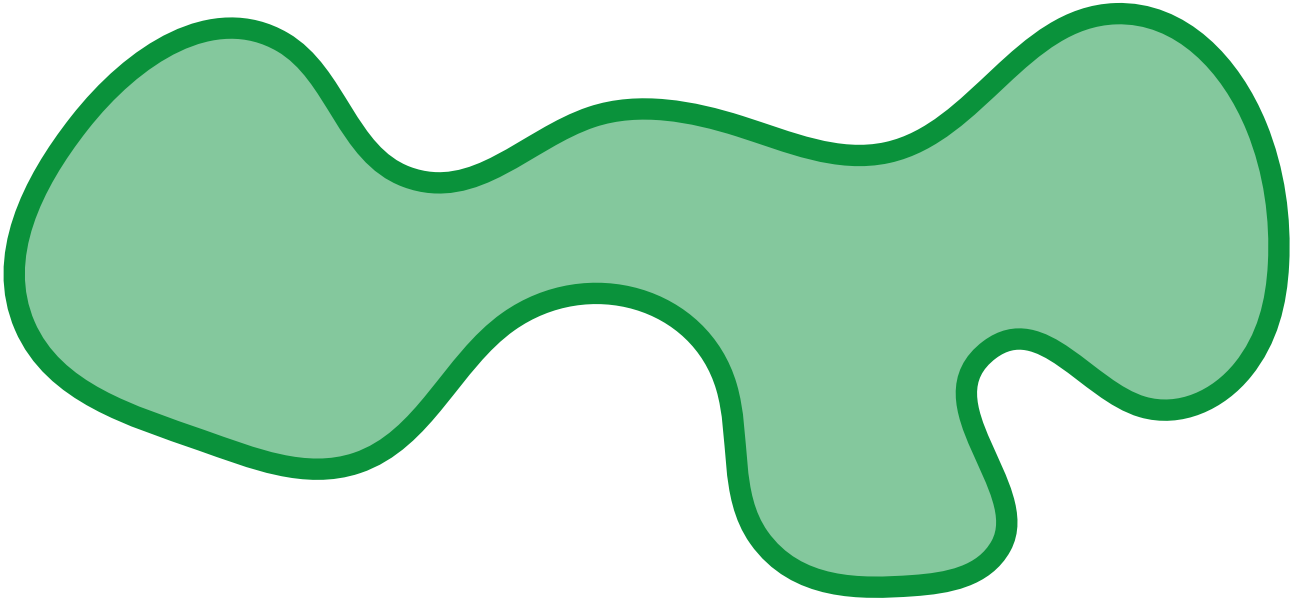

{ Head:∅, head:𝕊 }

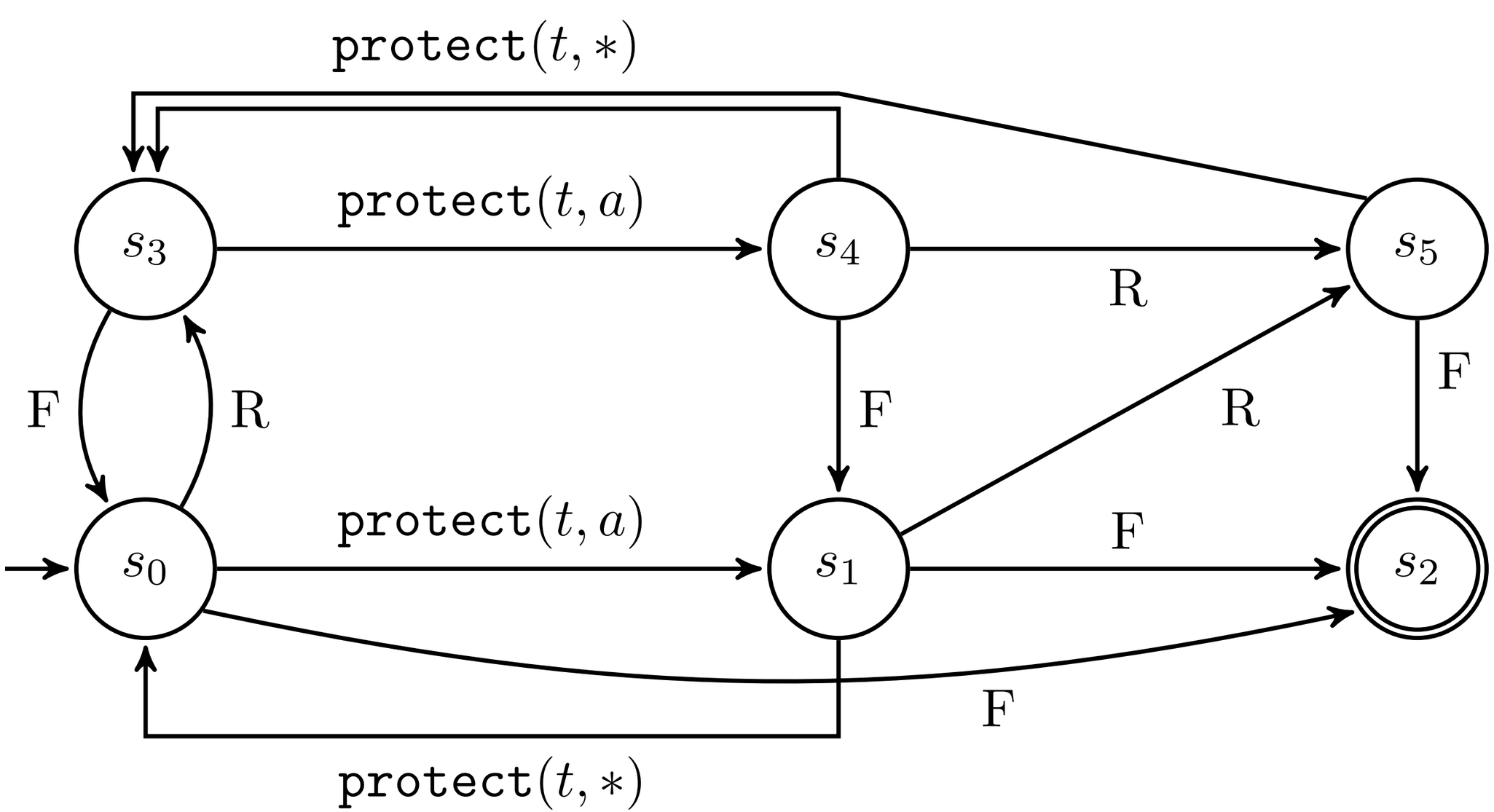
{ Head:∅, head:𝕊, next:∅ }

```
Node* head = Head;

protect(head);

atomic {

    @active Head

    assume(head == Head);



} // end atomic

// ...
Node* next = head->next;
```


Example

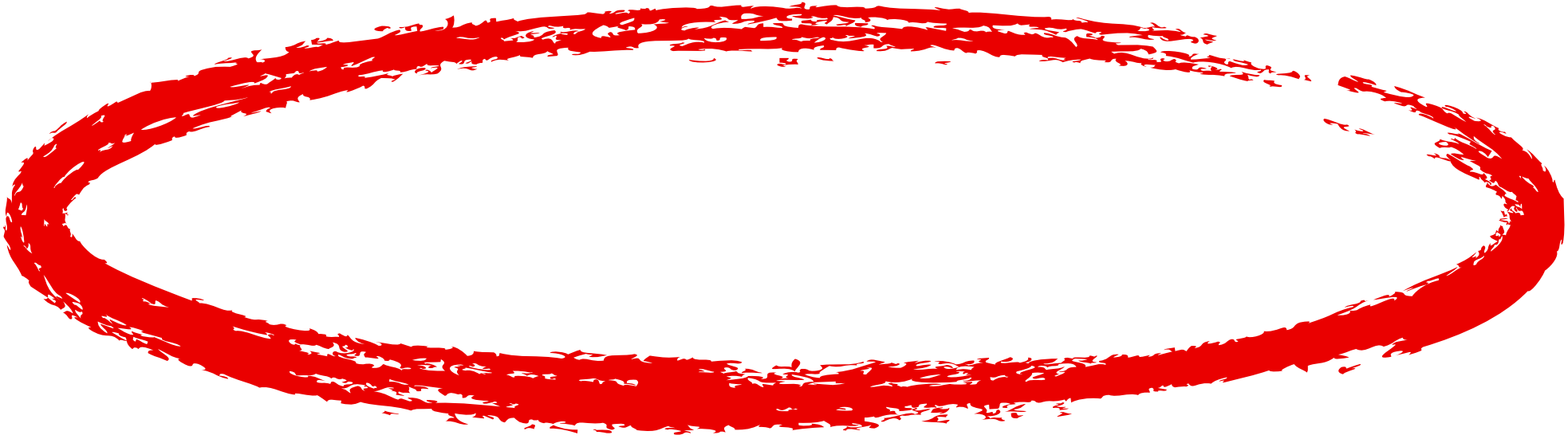
Type for head





$$F \;:=\; \texttt{free}(t, a) \vee \texttt{free}(*, a)$$

$$R \;:=\; \texttt{retire}(t, a) \vee \texttt{retire}(*, a)$$



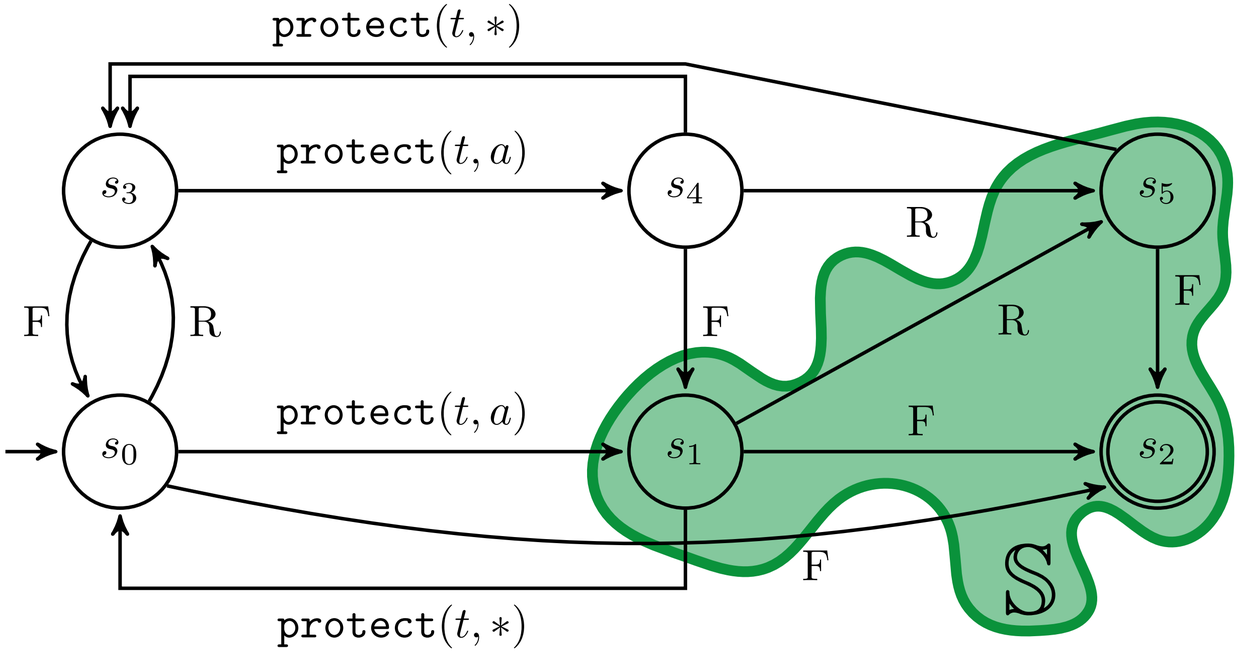
```
Node* head = Head;

protect(head);

atomic {

    @active Head

    assume(head == Head);



} // end atomic

// ...
Node* next = head->next;
```

{ Head:∅, head:𝕊, next:∅ }

Example

```
{ Head:𝔸, head:ℙ }
      assume(head == Head);
{ Head:ℙ ∧ 𝔸, head:ℙ ∧ 𝔸 }
{ Head:𝕊, head:𝕊 }
   } // end atomic
{ Head:∅, head:𝕊 }
   // ...
   Node* next = head->next;
{ Head:∅, head:𝕊, next:∅ }
```


Type for head



$$F := \texttt{free}(t,a) \vee \texttt{free}(*,a)$$

$$R := \texttt{retire}(t,a) \vee \texttt{retire}(*,a)$$

Experiments

Data Structure with HP	Types	Annot.	Lin.
Treiber's stack	0.7s ✓	12s ✓	1s ✓
Michael&Scott's queue	0.6s ✓	11s ✓	4s ✓
DGLM queue	0.6s ✓	1s ✗*	5s ✓
Vechev&Yahav's 2CAS set	1.2s ✓	13s ✓	98s ✓
Vechev&Yahav's CAS set	1.2s ✓	3.5h ✓	42m ✓
ORVYY set	1.2s ✓	3.2h ✓	47m ✓
Michael's set	1.2s ✓	90s ✗*	t/o

* imprecision in the back-end verifier