$termvar,\ x$ term variable

$index,\ i,\ j,\ k,\ n,\ m,\ p$

T ::=
- | **bool**
- | **int**
- | $\langle T1,..,Tn\rangle$
- | $T@\mathbf{r}$
- | $T@(r1,..,rn)$
- | $T@(r1,..,rk)$
- | **coloring** ($\mathbf{r}$)
- | **coloring** ($\mathbf{rp}$)
- | $\exists r1,..,rn.(T1,..,Tn), Phi, Q \rightarrow \mathbf{Tr}$

Om ::=
- | $\{o1,..,on\}$

om ::=
- | $r1 \leq r2$
- | $r1 \times r2$

Phi ::=
- | $\{phi1,..,phin\}$

phi ::=
- | **reads** ($\mathbf{r}$)
- | **writes** ($\mathbf{r}$)
- | **reducesid** ($\mathbf{r}$)

Q ::=
- | $\{q1,..,qn\}$

q ::=
- | **atomic** ($\mathbf{r}$)
- | **simult** ($\mathbf{r}$)

v ::=
- | bv
- | iv
- | $\langle v_1, v_2\rangle$
- | **null**
- | **l**
- | $\langle\langle rho1,..,rhon, v\rangle\rangle$

bv ::=
- | **true**   constant true
- | **false**   constant false

iv ::=
- | 0

| **S** *iv*

e ::=
| x
| iv
| bv
| $\langle e1, .., en \rangle$
| $e\ iv$
| **id**
| **new** T @ **r**
| **null** T @ **r**
| **isnull** (e)
| **upregion** $(e, r1, .., rn)$
| **downregion** $(e, r1, .., rn)$
| **read** (e)
| **write** (e_1, e_2)
| **reduce** $(\,\textbf{id}\,, e_1, e_2)$
| **newcolor r**
| **color** (e_1, e_2, e_3)
| $e_1 + e_2$
| $e_1 < e_2$
| **let id** : $T = e_1 \in e_2$
| **if b then** $c0$ **else** $c1$ conditional
| **id** $[r1, .., rn](e1, .., en)$
| **partition rp using** e_1 **as** $r1, .., rn \in e_2$
| **pack** e_1 **as** $T[r1, .., rn]$
| **unpack** e_1 **as id** : $T[r1, .., rn] \in e_2$

$logic$ ::=
| $\forall\, i, phi \in Phi$
| $\exists\, i.phi \in Phi$

$terminals$ ::=
| $\exists$
| $\forall$
| $\in$
| Ω
| ω
| Φ
| ϕ
| ρ
| $\vee$
| $\wedge$
| $\neg$
| $\leq$
| $\longrightarrow$
| $\rightarrow$

	$\Rightarrow$
	λ
	$\mapsto$
	$\vdash$
	$\varnothing$
	$\times$
	$<:$
	$\langle$
	$\rangle$
	$<$
	$\Downarrow$
	σ
	Γ
	ε

formula   ::=
| *judgement*

Jtype   ::=
| $\Gamma\,,\,\Phi\,,\,\Omega\vdash e:T$ Typing

Jop   ::=
| $p\longrightarrow p'$ Evaluation

judgement   ::=
| *Jtype*
| *Jop*

user_syntax   ::=
| *termvar*
| *index*
| *T*
| *Om*
| *om*
| *Phi*
| *phi*
| *Q*
| *q*
| *v*
| *bv*
| *iv*
| *e*
| *logic*
| *terminals*

$\boxed{\Gamma\,,\,\Phi\,,\,\Omega\vdash e:T}$ Typing

$$\frac{\Gamma\,,\,\Phi\,,\,\Omega\vdash e_1:T@(r1,..,rn)}{\Gamma\,,\,\Phi\,,\,\Omega\vdash\textbf{read}\,(e_1):T}\quad\text{T\_READ}$$

$$\frac{\Gamma,\Phi,\Omega \vdash e_1 : T@(r1,..,rn) \qquad \Gamma,\Phi,\Omega \vdash e_2 : T}{\Gamma,\Phi,\Omega \vdash \mathbf{write}\,(e_1,e_2) : T@(r1,..,rn)} \quad \text{T\_WRITE}$$

$$\frac{\Gamma,\Phi,\Omega \vdash e_1 : T@(r1,..,rn) \qquad \Gamma,\Phi,\Omega \vdash e_2 : T}{\Gamma,\Phi,\Omega \vdash \mathbf{reduce}\,(\mathbf{id},e_1,e_2) : T_1@(r1,..,rn)} \quad \text{T\_REDUCE}$$

$$\frac{}{\Gamma,\Phi,\Omega \vdash \mathbf{new}\,T@\,\mathbf{r} : T@\,\mathbf{r}} \quad \text{T\_NEW}$$

$$\frac{\Gamma,\Phi,\Omega \vdash e : T@(r1,..,rk)}{\Gamma,\Phi,\Omega \vdash \mathbf{upregion}\,(e_1,r1,..,rn) : T@(r1,..,rn)} \quad \text{T\_UPRGN}$$

$$\frac{\Gamma,\Phi,\Omega \vdash e : T@(r1,..,rk)}{\Gamma,\Phi,\Omega \vdash \mathbf{downregion}\,(e,r1,..,rn) : T@(r1,..,rn)} \quad \text{T\_DNRGN}$$

$$\frac{}{\Gamma,\Phi,\Omega \vdash \mathbf{newcolor}\,\mathbf{r} : T@\,\mathbf{r}} \quad \text{T\_NEWCOLOR}$$

$$\frac{\Gamma,\Phi,\Omega \vdash e_1 : T@(r1,..,rn) \qquad \Gamma,\Phi,\Omega \vdash e_2 : T@\,\mathbf{r} \qquad \Gamma,\Phi,\Omega \vdash e_3 : \mathbf{int}}{\Gamma,\Phi,\Omega \vdash \mathbf{color}\,(e_1,e_2,e_3) : \mathbf{coloring}\,(\mathbf{r})} \quad \text{T\_COLOR}$$

$\Gamma,\Phi,\Omega \vdash e_1 : \mathbf{coloring}\,(\mathbf{rp})$
$\Gamma,\Phi,\Omega \vdash e_2 : T$

<<no parses (char 42): G,P,O |- partition rp using e1 as r1,..,rk*** in e2: T >> T_PARTITI

$\Gamma,\Phi,\Omega \vdash e_3 : \mathbf{int}$

<<no parses (char 31): G,P,O |- pack e1 as T1[r1,..,rk***]:T1 >> T_PACK

$\Gamma,\Phi,\Omega \vdash e_1 : T_1$
<<no parses (char 2): G'***,P,O' |- e2 : T3 >>

<<no parses (char 37): G,P,O |- unpack e1 as id: T1[r1,..,rk***] in e2:T3 >> T_UNPACK

<<no parses (char 17): G,P,O |- ei : Ti[***r1/r1',..,rk/rk'] >>

<<no parses (char 20): G,P,O |- id[r1,..,rk***](e1,..,en):Tr[r1/r1',..,rk/rk'] >> T_CALL

$\Gamma,\Phi,$

<<no parses (char 1): |***- {function id1[r11,..,rk11](a11:T11,..,a1n1), P1,Q1,T1r:e1,... {

$\boxed{p \longrightarrow p'}$ Evaluation

<<no parses (char 1): s***tate,T,E[x := a] --> state,T,E[skip] >> E_SET

<<no parses (char 1): s***tate, T, E[skip;c] --> state,T,E[c] >> E_SKIP

<<no parses (char 1): s***tate, T, E[if b then c0 else c1] --> state,T,E[c0] >> E_IFTRUE

<<no parses (char 1): s***tate, T, E[if b then c0 else c1] --> state,T,E[c1] >> E_IFFALSE

<<no parses (char 1): s***tate, T, E[while b do c] --> state,T,E[if b then (c; while b do c)

<<no parses (char 1): s***tate, T, E[async c] --> state,T,E[skip] >> E_ASYNC

<<no parses (char 1): s***tate, T, E[yield] --> state,T,E[skip] >> E_YIELD

$$\frac{}{\text{<<no parses (char 1): s***tate,T,E[mkpar e] --> state,T,E[skip] >>}} \quad \text{E\_MkPar}$$

$$\frac{}{\text{<<no parses (char 1): s***tate,T,E[apply e1 e2] --> state,T,E[skip] >>}} \quad \text{E\_Apply}$$

$$\frac{}{\text{<<no parses (char 1): s***tate,T,E[if e1 at e2 then e3 else e4] --> state,T,E[skip] >>}} \quad \text{E\_If}$$

$$\frac{}{\text{<<no parses (char 1): s***tate,T,E[put e] --> state,T,E[skip] >>}} \quad \text{E\_Put}$$

$$\frac{}{\text{<<no parses (char 1): s***tate,T,E[get e1 e2] --> state,T,E[skip] >>}} \quad \text{E\_Get}$$

```
Definition rules:        8 good     17 bad
Definition rule clauses: 23 good     19 bad
```