metavariable, x, y

term, t, u	::=			term
	|	v		value
	|	x		variable
	|	$\mathsf{t}\ \mathsf{u}$		application
	|	$\mathsf{t}\ ⨟\ \mathsf{u}$		effect sequencing
	|	$\mathsf{case}\ \mathsf{t}\ \mathsf{of}\ \{\star \mapsto \mathsf{u}\}$		pattern-matching on unit
	|	$\mathsf{case}\ \mathsf{t}\ \mathsf{of}\ \{\ \mathsf{Ur}\ \mathsf{x} \mapsto \mathsf{u}\}$		pattern-matching on exponentiated value
	|	$\mathsf{case}\ \mathsf{t}\ \mathsf{of}\ \{\ \mathsf{Inl}\ \mathsf{x}_1 \mapsto \mathsf{u}_1,\ \mathsf{Inr}\ \mathsf{x}_2 \mapsto \mathsf{u}_2\}$		pattern-matching on sum
	|	$\mathsf{case}\ \mathsf{t}\ \mathsf{of}\ \{\langle \mathsf{x}_1, \mathsf{x}_2\rangle \mapsto \mathsf{u}\}$		pattern-matching on product
	|	$\mathsf{case}\ \mathsf{t}\ \mathsf{of}\ \{@\mathsf{R}\ \mathsf{x} \mapsto \mathsf{u}\}$		unroll for recursive types
	|	$\mathsf{alloc}_{\mathsf{D}}\ \mathsf{x}\,.\,\mathsf{t}$		allocate data
	|	$\mathsf{t} \triangleleft^{p}\ \star$		fill destination with unit
	|	$\mathsf{t} \triangleleft^{p}\ \lambda \mathsf{x} : \mathsf{A}\,.\,\mathsf{u}$		fill destination with function
	|	$\mathsf{t} \triangleleft^{p}\ \mathsf{u}$		
	|	$\mathsf{t} \triangleleft^{p}\ \mathsf{Ur}\ \mathsf{y}\,.\,\mathsf{u}$		fill destination with exponential
	|	$\mathsf{t} \triangleleft^{p}\ \mathsf{Inl}\ \mathsf{y}\,.\,\mathsf{u}$		fill sum-type destination with variant 1
	|	$\mathsf{t} \triangleleft^{p}\ \mathsf{Inr}\ \mathsf{y}\,.\,\mathsf{u}$		fill sum-type destination with variant 2
	|	$\mathsf{t} \triangleleft^{p}\ \langle \mathsf{y}_1, \mathsf{y}_2\rangle\,.\,\mathsf{u}$		fill product-type destination
	|	$\mathsf{t} \triangleleft^{p}\ @\mathsf{R}\ \mathsf{y}\,.\,\mathsf{u}$		fill destination with recursive type
	|	(t)	S	
	|	$\mathsf{t}[\mathsf{subs}]$	M	
hole, h	::=			
val, v	::=			unreducible value
	|	$\bullet$		no-effect effect
	|	d		data structure
data, d	::=			
	|	$\lfloor h \rfloor$		
	|	$\star$		
	|	$\lambda \mathsf{x} : \mathsf{A}\,.\,\mathsf{t}$		
	|	$\mathsf{Ur}\ \mathsf{d}$		
	|	$\mathsf{Inl}\ \mathsf{d}$		
	|	$\mathsf{Inr}\ \mathsf{d}$		
	|	$\langle \mathsf{d}_1, \mathsf{d}_2\rangle$		
	|	$@\mathsf{R}\ \mathsf{d}$		
	|	(d)	S	
multiplicity, p	::=			multiplicity
	|	1		
	|	ω		
sub	::=			substitution
	|	$\mathsf{x} := \mathsf{t}$		
	|	$h := \underline{\mathsf{d}}$		
subs	::=			substitutions
	|	sub		

	|	sub, subs		
data_with_hole, $\underline{\mathsf{d}}$	::=			
	|	d		
	|	h		
	|	Ur $\underline{\mathsf{d}}$		
	|	Inl $\underline{\mathsf{d}}$		
	|	Inr $\underline{\mathsf{d}}$		
	|	$\langle \underline{\mathsf{d}}_1, \underline{\mathsf{d}}_2 \rangle$		
	|	@R $\underline{\mathsf{d}}$		
	|	$(\underline{\mathsf{d}})$	S	
store_affect, sa	::=			store cell
	|	$\mathsf{x} : \mathsf{D} = \underline{\mathsf{d}}$		
store_affects	::=			store cells
	|	sa		
	|	sa, store_affects		
store, $\mathbb{S}$	::=			store contents
	|	$\emptyset$		
	|	{store_affects}		
	|	$\mathbb{S}_1 \sqcup \mathbb{S}_2$		
	|	$\mathbb{S}$[subs]	M	
type, A	::=			
	|	$\perp$		bottom type
	|	D		data type
data_type, D	::=			
	|	1		unit type
	|	R		recursive type bound to a name
	|	$\mathsf{D}_1 \otimes \mathsf{D}_2$		product type
	|	$\mathsf{D}_1 \oplus \mathsf{D}_2$		sum type
	|	$\mathsf{A}_1 \multimap \mathsf{A}_2$		linear function type
	|	$\lfloor \mathsf{D} \rfloor^p$		destination type
	|	!D		exponential
	|	(D)	S	
	|	$\underline{\mathsf{D}}[\mathsf{X} := \mathsf{D}]$	M	
type_with_var, $\underline{\mathsf{A}}$	::=			
	|	$\perp$		
	|	$\underline{\mathsf{D}}$		
data_type_with_var, $\underline{\mathsf{D}}$	::=			
	|	X		type variable in recursive definition
	|	1		unit type
	|	R		recursive type bound to a name
	|	$\underline{\mathsf{D}}_1 \otimes \underline{\mathsf{D}}_2$		product type

	$\mid$	$\underline{D}_1 \oplus \underline{D}_2$	sum type
	$\mid$	$\underline{A}_1 \multimap \underline{A}_2$	linear function type
	$\mid$	$\lfloor \underline{D} \rfloor^{p}$	destination type
	$\mid$	$!\underline{D}$	exponential
	$\mid$	$(\underline{D})$	S
rec_type_bound, R	::=		recursive type bound to a name
rec_type_def	::=		
	$\mid$	$\mu X . \underline{D}$	
type_affect, ta	::=		type affectation
	$\mid$	$x : A$	variable
	$\mid$	$h\ {}^{p}\!: D$	hole
type_affects	::=		type affectations
	$\mid$	ta	
	$\mid$	ta, type_affects	
typing_context, Γ, $\mho$, H, H_{P}, H_{N}	::=		typing context
	$\mid$	$\emptyset$	
	$\mid$	{type_affects}	
	$\mid$	$\Gamma_1 \sqcup \Gamma_2$	
command	::=		
	$\mid$	$\mathbb{S} \mid t$	
terminals	::=		
	$\mid$	$()$	
	$\mid$	$\mapsto$	
	$\mid$	$\oplus$	
	$\mid$	$\multimap$	
	$\mid$	$:=$	
	$\mid$	$\vdash$	
	$\mid$	$\dashv$	
	$\mid$	$\sqcup$	
	$\mid$	$\emptyset$	
	$\mid$	$\neq$	
	$\mid$	$\in$	
	$\mid$	$\notin$	
	$\mid$	\n	
	$\mid$	$\langle$	
	$\mid$	$\rangle$	
	$\mid$	Inl	
	$\mid$	Inr	
	$\mid$	Ur	
	$\mid$	Dest	
	$\mid$	$\triangleleft$	
	$\mid$	$\mid$	

	|	$\overset{c}{\prec}$
	|	$\Downarrow$
	|	$\overset{\text{fix}}{=}$
	|	$\perp$
	|	$\bullet$
	|	$\subset$
	|	$\mathcal{N}$
	|	$\Longrightarrow$
	|	@
	|	$\wedge$
formula	::=	
	|	judgement
Ctx	::=	
	|	$\mathsf{x} \in \mathcal{N}(\Gamma)$
	|	$\mathsf{x} \notin \mathcal{N}(\Gamma)$
	|	type_affect $\in \Gamma$
	|	$\mathcal{N}(\Gamma_1) \cap \mathcal{N}(\Gamma_2) = \emptyset$ — Γ_1 and Γ_2 are disjoint typing contexts with no
	|	$p_1 = p_2 \Longrightarrow \Gamma_1 = \Gamma_2$
	|	$p_1 = p_2 \Longrightarrow (\Gamma_1 = \Gamma_2 \wedge \Gamma_3 = \Gamma_4)$
Store	::=	
	|	fresh h
	|	store_affect $\in \mathbb{S}$
	|	$\mathsf{x} \notin \mathcal{N}(\mathbb{S})$
Eq	::=	
	|	$\mathsf{A}_1 = \mathsf{A}_2$
	|	$\mathsf{A}_1 \neq \mathsf{A}_2$
	|	$\mathsf{t} = \mathsf{u}$
	|	$\Gamma = \mathsf{D}$
Ty	::=	
	|	$\mathsf{R} \overset{\text{fix}}{=}$ rec_type_def
	|	$\mho\ ;\ \Gamma \vdash$ command : A
	|	$\mathrm{H_N} \vdash \underline{\mathsf{d}}\ ^{p}\!\!:\ \mathsf{D} \vdash \mathrm{H_P}$ — $\mathrm{H_P}$ stands for "provides", $\mathrm{H_N}$ for "needs"
	|	$\mathbb{S} \vdash \mathrm{H}$
	|	$\mho\ ;\ \mathrm{H} \sqcup \Gamma \vdash \mathsf{t} : \mathsf{A}$
Sem	::=	
	|	command $\Downarrow$ command$'$
judgement	::=	
	|	Ctx
	|	Store
	|	Eq
	|	Ty
	|	Sem

user_syntax ::=

| metavariable
| term
| *hole*
| val
| data
| *multiplicity*
| sub
| subs
| data_with_hole
| store_affect
| store_affects
| store
| type
| data_type
| type_with_var
| data_type_with_var
| rec_type_bound
| rec_type_def
| type_affect
| type_affects
| typing_context
| command
| terminals

$\boxed{x \in \mathcal{N}(\Gamma)}$

$\boxed{x \notin \mathcal{N}(\Gamma)}$

$\boxed{\text{type\_affect} \in \Gamma}$

$\boxed{\mathcal{N}(\Gamma_1) \cap \mathcal{N}(\Gamma_2) = \emptyset}$ Γ_1 and Γ_2 are disjoint typing contexts with no clashing variable names or labels

$\boxed{p_1 = p_2 \implies \Gamma_1 = \Gamma_2}$

$\boxed{p_1 = p_2 \implies (\Gamma_1 = \Gamma_2 \wedge \Gamma_3 = \Gamma_4)}$

$\boxed{\text{fresh } h}$

$\boxed{\text{store\_affect} \in \mathbb{S}}$

$\boxed{x \notin \mathcal{N}(\mathbb{S})}$

$\boxed{A_1 = A_2}$

$\boxed{A_1 \neq A_2}$

$\boxed{t = u}$

$\boxed{\Gamma = D}$

$\boxed{R \overset{\text{fix}}{=} \text{rec\_type\_def}}$

$\boxed{\mho \,;\, \Gamma \vdash \text{command} : A}$

$$\frac{\mathbb{S} \vdash H \qquad \mho \,;\, H \sqcup \Gamma \vdash t : A}{\mho \,;\, \Gamma \vdash \mathbb{S} \,|\, t : A} \quad \textsc{TyComm\_Def}$$

$\boxed{H_N \vdash \underline{d} \stackrel{p}{:} D \vdash H_P}$ H_P stands for "provides", H_N for "needs"

$$\frac{}{\emptyset \vdash h \;{}^{p}\!:\; D \vdash \{h \;{}^{p}\!:\; D\}}\;\textsc{TyDh\_H}$$

$$\frac{}{\{h \;{}^{p}\!:\; D\} \vdash \lfloor h \rfloor \;{}^{1}\!:\; \lfloor D \rfloor^{p} \vdash \emptyset}\;\textsc{TyDh\_Dest}$$

$$\frac{}{\emptyset \vdash \star \;{}^{p}\!:\; 1 \vdash \emptyset}\;\textsc{TyDh\_U}$$

$$\frac{\begin{array}{c}\emptyset \;;\; \mathrm{H_N} \sqcup \{x : A_1\} \vdash t : A_2 \\ p = \omega \implies \mathrm{H_N} = \emptyset\end{array}}{\mathrm{H_N} \vdash \lambda x : D \,.\, t \;{}^{p}\!:\; A_1 \multimap A_2 \vdash \emptyset}\;\textsc{TyDh\_Fn}$$

$$\frac{\mathrm{H_N} \vdash \underline{d} \;{}^{\omega}\!:\; D \vdash \mathrm{H_P}}{\mathrm{H_N} \vdash \mathsf{Ur}\;\underline{d} \;{}^{p}\!:\; !D \vdash \mathrm{H_P}}\;\textsc{TyDh\_E}$$

$$\frac{\mathrm{H_N} \vdash \underline{d} \;{}^{p}\!:\; D_1 \vdash \mathrm{H_P}}{\mathrm{H_N} \vdash \mathsf{Inl}\;\underline{d} \;{}^{p}\!:\; D_1 \oplus D_2 \vdash \mathrm{H_P}}\;\textsc{TyDh\_Inl}$$

$$\frac{\mathrm{H_N} \vdash \underline{d} \;{}^{p}\!:\; D_2 \vdash \mathrm{H_P}}{\mathrm{H_N} \vdash \mathsf{Inr}\;\underline{d} \;{}^{p}\!:\; D_1 \oplus D_2 \vdash \mathrm{H_P}}\;\textsc{TyDh\_Inr}$$

$$\frac{\begin{array}{c}\mathrm{H_{N1}} \vdash \underline{d_1} \;{}^{p}\!:\; D_1 \vdash \mathrm{H_{P1}} \\ \mathrm{H_{N2}} \vdash \underline{d_2} \;{}^{p}\!:\; D_2 \vdash \mathrm{H_{P2}}\end{array}}{\mathrm{H_{N1}} \sqcup \mathrm{H_{N2}} \vdash \langle \underline{d_1}, \underline{d_2} \rangle \;{}^{p}\!:\; D_1 \otimes D_2 \vdash \mathrm{H_{P1}} \sqcup \mathrm{H_{P2}}}\;\textsc{TyDh\_P}$$

$$\frac{\begin{array}{c}R \overset{\mathsf{fix}}{=} \mu X \,.\, \underline{D} \\ \mathrm{H_N} \vdash \underline{d} \;{}^{p}\!:\; \underline{D}[X := R] \vdash \mathrm{H_P}\end{array}}{\mathrm{H_N} \vdash @R\;\underline{d} \;{}^{p}\!:\; R \vdash \mathrm{H_P}}\;\textsc{TyDh\_R}$$

$\boxed{\mathbb{S} \vdash \mathrm{H}}$

$$\frac{}{\emptyset \vdash \emptyset}\;\textsc{TyStore\_Empty}$$

$$\frac{\begin{array}{c}\mathbb{S} \vdash \mathrm{H} \sqcup \mathrm{H_N} \\ \mathrm{H_N} \vdash \underline{d} \;{}^{1}\!:\; D \vdash \mathrm{H_P}\end{array}}{\mathbb{S} \sqcup \{x : D = \underline{d}\} \vdash \mathrm{H} \sqcup \mathrm{H_P}}\;\textsc{TyStore\_Root}$$

$\boxed{\mho \;;\; \mathrm{H} \sqcup \Gamma \vdash t : A}$

$$\frac{}{\mho \;;\; \emptyset \sqcup \emptyset \vdash \bullet : \bot}\;\textsc{TyTerm\_NoEff}$$

$$\frac{}{\mho \;;\; \{h \;{}^{p}\!:\; D\} \sqcup \emptyset \vdash \lfloor h \rfloor : \lfloor D \rfloor^{p}}\;\textsc{TyTerm\_Dest}$$

$$\frac{}{\mho \;;\; \emptyset \sqcup \emptyset \vdash \star : 1}\;\textsc{TyTerm\_U}$$

$$\frac{\emptyset \;;\; \mathrm{H} \sqcup \{x : A_1\} \vdash t : A_2}{\mho \;;\; \mathrm{H} \sqcup \emptyset \vdash \lambda x : A_1 \,.\, t : A_1 \multimap A_2}\;\textsc{TyTerm\_Fn}$$

$$\frac{\emptyset \;;\; \emptyset \sqcup \emptyset \vdash d : D}{\mho \;;\; \emptyset \sqcup \emptyset \vdash \mathsf{Ur}\; d : !D}\;\textsc{TyTerm\_E}$$

$$\frac{\emptyset \;;\; \mathrm{H} \sqcup \emptyset \vdash d : D_1}{\mho \;;\; \mathrm{H} \sqcup \emptyset \vdash \mathsf{Inl}\; d : D_1 \oplus D_2}\;\textsc{TyTerm\_Inl}$$

$$\frac{\emptyset \;;\; \mathrm{H} \sqcup \emptyset \vdash d : D_2}{\mho \;;\; \mathrm{H} \sqcup \emptyset \vdash \mathsf{Inr}\; d : D_1 \oplus D_2}\;\textsc{TyTerm\_Inr}$$

$$\frac{\emptyset\ ;\ H_1 \mathbin{\scriptstyle\sqcup} \emptyset \vdash d_1 : D_1 \qquad \emptyset\ ;\ H_2 \mathbin{\scriptstyle\sqcup} \emptyset \vdash d_2 : D_2}{\mho\ ;\ H_1 \sqcup H_2 \mathbin{\scriptstyle\sqcup} \emptyset \vdash \langle d_1, d_2\rangle : D_1 \otimes D_2}\ \textsc{TyTerm\_P}$$

$$\frac{R \overset{\text{fix}}{=} \mu X\,.\,\underline{D} \qquad \emptyset\ ;\ H \mathbin{\scriptstyle\sqcup} \emptyset \vdash d : \underline{D}[X := R]}{\mho\ ;\ H \mathbin{\scriptstyle\sqcup} \emptyset \vdash @R\, d : R}\ \textsc{TyTerm\_R}$$

$$\frac{}{\mho\ ;\ \emptyset \mathbin{\scriptstyle\sqcup} \{x : A\} \vdash x : A}\ \textsc{TyTerm\_Id}$$

$$\frac{}{\mho \sqcup \{x : A\}\ ;\ \emptyset \mathbin{\scriptstyle\sqcup} \emptyset \vdash x : A}\ \textsc{TyTerm\_Id'}$$

$$\frac{\mho\ ;\ H_1 \mathbin{\scriptstyle\sqcup} \Gamma_1 \vdash t : A_1 \multimap A_2 \qquad \mho\ ;\ H_2 \mathbin{\scriptstyle\sqcup} \Gamma_2 \vdash u : A_1}{\mho\ ;\ H_1 \sqcup H_2 \mathbin{\scriptstyle\sqcup} \Gamma_1 \sqcup \Gamma_2 \vdash t\ u : A_2}\ \textsc{TyTerm\_App}$$

$$\frac{\mho\ ;\ H_1 \mathbin{\scriptstyle\sqcup} \Gamma_1 \vdash t : \bot \qquad \mho\ ;\ H_2 \mathbin{\scriptstyle\sqcup} \Gamma_2 \vdash u : A_2}{\mho\ ;\ H_1 \sqcup H_2 \mathbin{\scriptstyle\sqcup} \Gamma_1 \sqcup \Gamma_2 \vdash t \fatsemi u : A_2}\ \textsc{TyTerm\_EffSeq}$$

$$\frac{\mho\ ;\ H_1 \mathbin{\scriptstyle\sqcup} \Gamma_1 \vdash t : 1 \qquad \mho\ ;\ H_2 \mathbin{\scriptstyle\sqcup} \Gamma_2 \vdash u : A}{\mho\ ;\ H_1 \sqcup H_2 \mathbin{\scriptstyle\sqcup} \Gamma_1 \sqcup \Gamma_2 \vdash \mathsf{case}\ t\ \mathsf{of}\ \{\star \mapsto u\} : A}\ \textsc{TyTerm\_PatU}$$

$$\frac{\mho\ ;\ H_1 \mathbin{\scriptstyle\sqcup} \Gamma_1 \vdash t : !D \qquad \mho \sqcup \{x : D\}\ ;\ H_2 \mathbin{\scriptstyle\sqcup} \Gamma_2 \vdash u : A}{\mho\ ;\ H_1 \sqcup H_2 \mathbin{\scriptstyle\sqcup} \Gamma_1 \sqcup \Gamma_2 \vdash \mathsf{case}\ t\ \mathsf{of}\ \{\ \mathsf{Ur}\ x \mapsto u\} : A}\ \textsc{TyTerm\_PatE}$$

$$\frac{\mho\ ;\ H_1 \mathbin{\scriptstyle\sqcup} \Gamma_1 \vdash t : D_1 \oplus D_2 \qquad \mho\ ;\ H_2 \mathbin{\scriptstyle\sqcup} \Gamma_2 \sqcup \{x_1 : D_1\} \vdash u_1 : A \qquad \mho\ ;\ H_2 \mathbin{\scriptstyle\sqcup} \Gamma_2 \sqcup \{x_2 : D_2\} \vdash u_2 : A}{\mho\ ;\ H_1 \sqcup H_2 \mathbin{\scriptstyle\sqcup} \Gamma_1 \sqcup \Gamma_2 \vdash \mathsf{case}\ t\ \mathsf{of}\ \{\ \mathsf{Inl}\ x_1 \mapsto u_1,\ \mathsf{Inr}\ x_2 \mapsto u_2\} : A}\ \textsc{TyTerm\_PatS}$$

$$\frac{\mho\ ;\ H_1 \mathbin{\scriptstyle\sqcup} \Gamma_1 \vdash t : D_1 \otimes D_2 \qquad \mho\ ;\ H_2 \mathbin{\scriptstyle\sqcup} \Gamma_2 \sqcup \{x_1 : D_1, x_2 : D_2\} \vdash u : A}{\mho\ ;\ H_1 \sqcup H_2 \mathbin{\scriptstyle\sqcup} \Gamma_1 \sqcup \Gamma_2 \vdash \mathsf{case}\ t\ \mathsf{of}\ \{\langle x_1, x_2\rangle \mapsto u\} : A}\ \textsc{TyTerm\_PatP}$$

$$\frac{R \overset{\text{fix}}{=} \mu X\,.\,\underline{D} \qquad \mho\ ;\ H_1 \mathbin{\scriptstyle\sqcup} \Gamma_1 \vdash t : R \qquad \mho\ ;\ H_2 \mathbin{\scriptstyle\sqcup} \Gamma_2 \sqcup \{x : \underline{D}[X := R]\} \vdash u : A}{\mho\ ;\ H_1 \sqcup H_2 \mathbin{\scriptstyle\sqcup} \Gamma_1 \sqcup \Gamma_2 \vdash \mathsf{case}\ t\ \mathsf{of}\ \{@R\, x \mapsto u\} : A}\ \textsc{TyTerm\_PatR}$$

$$\frac{\mho\ ;\ H \mathbin{\scriptstyle\sqcup} \Gamma \sqcup \{x : \lfloor D \rfloor^{\mathit{1}}\} \vdash t : \bot}{\mho\ ;\ H \mathbin{\scriptstyle\sqcup} \Gamma \vdash \underset{D}{\mathsf{alloc}}\ x\,.\,t : D}\ \textsc{TyTerm\_Alloc}$$

$$\frac{\mho\ ;\ H \mathbin{\scriptstyle\sqcup} \Gamma \vdash t : \lfloor 1 \rfloor^{p}}{\mho\ ;\ H \mathbin{\scriptstyle\sqcup} \Gamma \vdash t \triangleleft^{p} \star : \bot}\ \textsc{TyTerm\_FillU}$$

$$\frac{\mho\ ;\ H_1 \mathbin{\scriptstyle\sqcup} \Gamma_1 \vdash t : \lfloor A_1 \multimap A_2 \rfloor^{p} \qquad \mho\ ;\ H_2 \mathbin{\scriptstyle\sqcup} \Gamma_2 \sqcup \{x : A_1\} \vdash u : A_2 \qquad p = \omega \implies (H_2 = \emptyset \wedge \Gamma_2 = \emptyset)}{\mho\ ;\ H_1 \sqcup H_2 \mathbin{\scriptstyle\sqcup} \Gamma_1 \sqcup \Gamma_2 \vdash t \triangleleft^{p} \lambda x : A_1\,.\,u : \bot}\ \textsc{TyTerm\_FillFn}$$

$$\frac{\mho\ ;\ H_1 \mathbin{\scriptstyle\sqcup} \Gamma_1 \vdash t : \lfloor D \rfloor^{p} \qquad \mho\ ;\ H_2 \mathbin{\scriptstyle\sqcup} \Gamma_2 \vdash u : D \qquad p = \omega \implies (H_2 = \emptyset \wedge \Gamma_2 = \emptyset)}{\mho\ ;\ H_1 \sqcup H_2 \mathbin{\scriptstyle\sqcup} \Gamma_1 \sqcup \Gamma_2 \vdash t \triangleleft^{p} u : \bot}\ \textsc{TyTerm\_FillL}$$

$$\dfrac{\mho\ ;\ H_1 \uplus \Gamma_1 \vdash t : \lfloor !D \rfloor^{p} \qquad \mho\ ;\ H_2 \uplus \Gamma_2 \sqcup \{x : \lfloor D \rfloor^{\omega}\} \vdash u : A}{\mho\ ;\ H_1 \sqcup H_2 \uplus \Gamma_1 \sqcup \Gamma_2 \vdash t \triangleleft^{p}\ \mathsf{Ur}\ x\,.\,u : A}\ \textsc{TyTerm\_FillE}$$

$$\dfrac{\mho\ ;\ H_1 \uplus \Gamma_1 \vdash t : \lfloor D_1 \oplus D_2 \rfloor^{p} \qquad \mho\ ;\ H_2 \uplus \Gamma_2 \sqcup \{x : \lfloor D_1 \rfloor^{p}\} \vdash u : A}{\mho\ ;\ H_1 \sqcup H_2 \uplus \Gamma_1 \sqcup \Gamma_2 \vdash t \triangleleft^{p}\ \mathsf{Inl}\ x\,.\,u : A}\ \textsc{TyTerm\_FillInl}$$

$$\dfrac{\mho\ ;\ H_1 \uplus \Gamma_1 \vdash t : \lfloor D_1 \oplus D_2 \rfloor^{p} \qquad \mho\ ;\ H_2 \uplus \Gamma_2 \sqcup \{x : \lfloor D_2 \rfloor^{p}\} \vdash u : A}{\mho\ ;\ H_1 \sqcup H_2 \uplus \Gamma_1 \sqcup \Gamma_2 \vdash t \triangleleft^{p}\ \mathsf{Inr}\ x\,.\,u : A}\ \textsc{TyTerm\_FillInr}$$

$$\dfrac{\mho\ ;\ H_1 \uplus \Gamma_1 \vdash t : \lfloor D_1 \otimes D_2 \rfloor^{p} \qquad \mho\ ;\ H_2 \uplus \Gamma_2 \sqcup \{x_1 : \lfloor D_1 \rfloor^{p}, x_2 : \lfloor D_2 \rfloor^{p}\} \vdash u : A}{\mho\ ;\ H_1 \sqcup H_2 \uplus \Gamma_1 \sqcup \Gamma_2 \vdash t \triangleleft^{p}\ \langle x_1, x_2 \rangle\,.\,u : A}\ \textsc{TyTerm\_FillP}$$

$$\dfrac{R \overset{\mathsf{fix}}{=} \mu X\,.\,\underline{D} \qquad \mho\ ;\ H_1 \uplus \Gamma_1 \vdash t : \lfloor R \rfloor^{p} \qquad \mho\ ;\ H_2 \uplus \Gamma_2 \sqcup \{x : \lfloor \underline{D}[X := R] \rfloor^{p}\} \vdash u : A}{\mho\ ;\ H_1 \sqcup H_2 \uplus \Gamma_1 \sqcup \Gamma_2 \vdash t \triangleleft^{p}\ @R\ x\,.\,u : A}\ \textsc{TyTerm\_FillR}$$

$\boxed{\mathsf{command} \Downarrow \mathsf{command}'}$

$$\dfrac{}{\mathbb{S} \mid v \ \Downarrow\ \mathbb{S} \mid v}\ \textsc{SemOp\_Val}$$

$$\dfrac{\mathbb{S}_0 \mid t \ \Downarrow\ \mathbb{S}_1 \mid \lambda x : A\,.\,t' \qquad \mathbb{S}_1 \mid u \ \Downarrow\ \mathbb{S}_2 \mid v_2 \qquad \mathbb{S}_2 \mid t'[x := v_2] \ \Downarrow\ \mathbb{S}_3 \mid v_3}{\mathbb{S}_0 \mid t\ u \ \Downarrow\ \mathbb{S}_3 \mid v_3}\ \textsc{SemOp\_App}$$

$$\dfrac{\mathbb{S}_0 \mid t \ \Downarrow\ \mathbb{S}_1 \mid \bullet \qquad \mathbb{S}_1 \mid u \ \Downarrow\ \mathbb{S}_2 \mid v_2}{\mathbb{S}_0 \mid t \fatsemi u \ \Downarrow\ \mathbb{S}_2 \mid v_2}\ \textsc{SemOp\_EffSeq}$$

$$\dfrac{\mathbb{S}_0 \mid t \ \Downarrow\ \mathbb{S}_1 \mid \star \qquad \mathbb{S}_1 \mid u \ \Downarrow\ \mathbb{S}_2 \mid v_2}{\mathbb{S}_0 \mid \mathsf{case}\ t\ \mathsf{of}\ \{\star \mapsto u\} \ \Downarrow\ \mathbb{S}_2 \mid v_2}\ \textsc{SemOp\_PatU}$$

$$\dfrac{\mathbb{S}_0 \mid t \ \Downarrow\ \mathbb{S}_1 \mid \mathsf{Ur}\ d \qquad \mathbb{S}_1 \mid u[y := d] \ \Downarrow\ \mathbb{S}_2 \mid v_2}{\mathbb{S}_0 \mid \mathsf{case}\ t\ \mathsf{of}\ \{\ \mathsf{Ur}\ y \mapsto u\} \ \Downarrow\ \mathbb{S}_2 \mid v_2}\ \textsc{SemOp\_PatE}$$

$$\dfrac{\mathbb{S}_0 \mid t \ \Downarrow\ \mathbb{S}_1 \mid \mathsf{Inl}\ d \qquad \mathbb{S}_1 \mid u_1[y_1 := d] \ \Downarrow\ \mathbb{S}_2 \mid v_2}{\mathbb{S}_0 \mid \mathsf{case}\ t\ \mathsf{of}\ \{\ \mathsf{Inl}\ y_1 \mapsto u_1,\ \mathsf{Inr}\ y_2 \mapsto u_2\} \ \Downarrow\ \mathbb{S}_2 \mid v_2}\ \textsc{SemOp\_PatInl}$$

$$\dfrac{\mathbb{S}_0 \mid t \ \Downarrow\ \mathbb{S}_1 \mid \mathsf{Inr}\ d \qquad \mathbb{S}_1 \mid u_2[y_2 := d] \ \Downarrow\ \mathbb{S}_2 \mid v_2}{\mathbb{S}_0 \mid \mathsf{case}\ t\ \mathsf{of}\ \{\ \mathsf{Inl}\ y_1 \mapsto u_1,\ \mathsf{Inr}\ y_2 \mapsto u_2\} \ \Downarrow\ \mathbb{S}_2 \mid v_2}\ \textsc{SemOp\_PatInr}$$

$$\dfrac{\mathbb{S}_0 \mid t \ \Downarrow\ \mathbb{S}_1 \mid \langle d_1, d_2 \rangle \qquad \mathbb{S}_1 \mid u[y_1 := d_1, y_2 := d_2] \ \Downarrow\ \mathbb{S}_2 \mid v_2}{\mathbb{S}_0 \mid \mathsf{case}\ t\ \mathsf{of}\ \{\langle y_1, y_2 \rangle \mapsto u\} \ \Downarrow\ \mathbb{S}_2 \mid v_2}\ \textsc{SemOp\_PatP}$$

$$\dfrac{\mathbb{S}_0 \mid t \ \Downarrow\ \mathbb{S}_1 \mid @R\ d \qquad \mathbb{S}_1 \mid u[y := d] \ \Downarrow\ \mathbb{S}_2 \mid v_2}{\mathbb{S}_0 \mid \mathsf{case}\ t\ \mathsf{of}\ \{@R\ y \mapsto u\} \ \Downarrow\ \mathbb{S}_2 \mid v_2}\ \textsc{SemOp\_PatR}$$

$$\frac{\begin{array}{l}\text{fresh } h\\ \mathbb{S}_0 \sqcup \{x : D = h\} \mid t[x := \lfloor h \rfloor] \ \Downarrow\ \mathbb{S}_1 \sqcup \{x : D = d\} \mid \bullet\end{array}}{\mathbb{S}_0 \mid \text{alloc}_{D}\ x \,.\, t \ \Downarrow\ \mathbb{S}_1 \mid d} \quad \textsc{SemOp\_Alloc}$$

$$\frac{\mathbb{S}_0 \mid t \ \Downarrow\ \mathbb{S}_1 \mid \lfloor h \rfloor}{\mathbb{S}_0 \mid t \triangleleft^{p} \star \ \Downarrow\ \mathbb{S}_1[h := \star] \mid \bullet} \quad \textsc{SemOp\_FillU}$$

$$\frac{\mathbb{S}_0 \mid t \ \Downarrow\ \mathbb{S}_1 \mid \lfloor h \rfloor}{\mathbb{S}_0 \mid t \triangleleft^{p} \lambda x : A \,.\, u \ \Downarrow\ \mathbb{S}_1[h := \lambda x : A \,.\, u] \mid \bullet} \quad \textsc{SemOp\_FillFn}$$

$$\frac{\begin{array}{l}\mathbb{S}_0 \mid t \ \Downarrow\ \mathbb{S}_1 \mid \lfloor h \rfloor\\ \mathbb{S}_1 \mid u \ \Downarrow\ \mathbb{S}_2 \mid d_2\end{array}}{\mathbb{S}_0 \mid t \triangleleft^{p} u \ \Downarrow\ \mathbb{S}_2[h := d_2] \mid \bullet} \quad \textsc{SemOp\_FillL}$$

$$\frac{\begin{array}{l}\text{fresh } h'\\ \mathbb{S}_0 \mid t \ \Downarrow\ \mathbb{S}_1 \mid \lfloor h \rfloor\\ \mathbb{S}_1[h := \text{Ur } h'] \mid u[y := \lfloor h' \rfloor] \ \Downarrow\ \mathbb{S}_2 \mid v_2\end{array}}{\mathbb{S}_0 \mid t \triangleleft^{p} \text{Ur } y \,.\, u \ \Downarrow\ \mathbb{S}_2 \mid v_2} \quad \textsc{SemOp\_FillE}$$

$$\frac{\begin{array}{l}\text{fresh } h'\\ \mathbb{S}_0 \mid t \ \Downarrow\ \mathbb{S}_1 \mid \lfloor h \rfloor\\ \mathbb{S}_1[h := \text{Inl } h'] \mid u[y := \lfloor h' \rfloor] \ \Downarrow\ \mathbb{S}_2 \mid v_2\end{array}}{\mathbb{S}_0 \mid t \triangleleft^{p} \text{Inl } y \,.\, u \ \Downarrow\ \mathbb{S}_2 \mid v_2} \quad \textsc{SemOp\_FillInl}$$

$$\frac{\begin{array}{l}\text{fresh } h'\\ \mathbb{S}_0 \mid t \ \Downarrow\ \mathbb{S}_1 \mid \lfloor h \rfloor\\ \mathbb{S}_1[h := \text{Inr } h'] \mid u[y := \lfloor h' \rfloor] \ \Downarrow\ \mathbb{S}_2 \mid v_2\end{array}}{\mathbb{S}_0 \mid t \triangleleft^{p} \text{Inr } y \,.\, u \ \Downarrow\ \mathbb{S}_2 \mid v_2} \quad \textsc{SemOp\_FillInr}$$

$$\frac{\begin{array}{l}\text{fresh } h_1\\ \text{fresh } h_2\\ \mathbb{S}_0 \mid t \ \Downarrow\ \mathbb{S}_1 \mid \lfloor h \rfloor\\ \mathbb{S}_1[h := \langle h_1, h_2 \rangle] \mid u[y_1 := \lfloor h_1 \rfloor, y_2 := \lfloor h_2 \rfloor] \ \Downarrow\ \mathbb{S}_2 \mid v_2\end{array}}{\mathbb{S}_0 \mid t \triangleleft^{p} \langle y_1, y_2 \rangle \,.\, u \ \Downarrow\ \mathbb{S}_2 \mid v_2} \quad \textsc{SemOp\_FillP}$$

$$\frac{\begin{array}{l}\text{fresh } h'\\ \mathbb{S}_0 \mid t \ \Downarrow\ \mathbb{S}_1 \mid \lfloor h \rfloor\\ \mathbb{S}_1[h := @\text{R } h'] \mid u[y := \lfloor h' \rfloor] \ \Downarrow\ \mathbb{S}_2 \mid v_2\end{array}}{\mathbb{S}_0 \mid t \triangleleft^{p} @\text{R } x \,.\, u \ \Downarrow\ \mathbb{S}_2 \mid v_2} \quad \textsc{SemOp\_FillR}$$

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Definition rules:        57 good    0 bad
Definition rule clauses: 152 good    0 bad
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