Syntax

Types

$$
\begin{array}{lcl}
P & ::= & \top \mid p : \tau \, \langle \overline{x : \tau} \rangle \mid P \wedge P \\
\mathbb{T}\left(\mathbb{B}\right) & ::= & \alpha^{\mathbb{B}} \mid x{:}\mathbb{T}\left(\mathbb{B}\right) \to \mathbb{T}\left(\mathbb{B}\right) \ \mid \mathsf{TyCon}^{\mathbb{B}} \ \overline{\mathbb{T}\left(\mathbb{B}\right)} \ \overline{\mathbb{B}} \ \mid \mathsf{Class} \ \overline{\mathbb{T}\left(\mathbb{B}\right)} \\
\mathbb{P}\left(\mathbb{B}\right) & ::= & \forall P.\mathbb{P}\left(\mathbb{B}\right) \mid \mathbb{T}\left(\mathbb{B}\right) \\
\mathbb{S}\left(\mathbb{B}\right) & ::= & \forall \alpha.\mathbb{S}\left(\mathbb{B}\right) \mid \mathbb{P}\left(\mathbb{B}\right) \\
T_P & ::= & \mathbb{S}\left(P\right) \\
\hat{T} & ::= & \mathbb{S}\left(Q\right) \\
T & ::= & \mathbb{S}\left(E\right) \\
\tau & ::= & \mathbb{S}\left(\top\right) \\
e & ::= & \mathrm{x} \mid \mathrm{C} \mid e \ e \mid \lambda x.e \\
 & \mid & e \ @ \mid \hat{\Lambda} p.e \mid e \left[\tau\right] \mid \Lambda \alpha.e \\
 & \mid & \mathsf{case} \ x \ \mathsf{of} \ \ |_i \ C_i \ \overline{x_i} \ \ \to \ \ e_i \\
 & \mid & \mathsf{let} \ x = e \ \mathsf{in} \ e \mid \mathsf{letrec} \ x = e \ \mathsf{in} \ e
\end{array}
$$

Rules

$$\boxed{\Gamma \vdash_{P,Q} e : T}$$

$$\frac{\Gamma \vdash_{P,Q} e : T_1 \qquad \Gamma \vdash T_1 <: T_2 \qquad \Gamma \vdash T_2}{\Gamma \vdash_{P,Q} e : T_2}$$

$$\frac{\Gamma(x) = \{v : T \mid e\}}{\Gamma \vdash_{P,Q} x : \{v : T \mid e \wedge v = x\}}$$

$$\frac{}{\Gamma \vdash_{P,Q} \mathsf{C} : ty(c)}$$

$$\frac{\Gamma \vdash_{P,Q} e_1 : x{:}T_x \to T \qquad \Gamma \vdash_{P,Q} e_2 : T}{\Gamma \vdash_{P,Q} e_1 \ e_2 : T \left[x \mapsto e_2\right]}$$

$$\frac{\Gamma, x : \hat{T}_x \vdash_{P,Q} e : \hat{T} \qquad \Gamma \vdash x{:}\hat{T}_x \to \hat{T}}{\Gamma \vdash_{P,Q} \lambda x.e : x{:}\hat{T}_x \to \hat{T}}$$

$$\frac{\Gamma \vdash_{P,Q} e : \forall p.T \qquad e_p = \text{fresh } \ (p) \qquad \Gamma, p \vdash e_p}{\Gamma \vdash_{P,Q} e \ @ : T \left[p \mapsto e_p\right]}$$

define : freshP, subP
do I need the following rule?

$$\frac{\Gamma \vdash_{P,Q} e : T}{\Gamma \vdash_{P,Q} \hat{\Lambda} p.e : \forall p.T}$$

$$\frac{\Gamma \vdash_{P,Q} e : \forall \alpha.T \qquad \hat{T} = \text{fresh } \ (\tau)}{\Gamma \vdash_{P,Q} e \left[\tau\right] : T \left[\alpha \mapsto \hat{T}\right]}$$

define subT, freshT

$$\frac{\Gamma \vdash_{P,Q} e : T \qquad \alpha \notin \Gamma}{\Gamma \vdash_{P,Q} \Lambda \alpha . e : \forall \alpha . T}$$

$$\frac{\begin{array}{c}\Gamma \vdash_{P,Q} e : \mathsf{C}^{e_c}\ \overline{T}\ \overline{e} \\ \forall i . \{\Gamma \vdash_{P,Q} \mathsf{C}_i : \underline{\forall \overline{\alpha} . \forall \overline{p} . y_1{:}T_1 \to \dots y_j{:}T_j} \to \dots y_n{:}T_n \to \mathsf{C}^{e'_c}\ \overline{T'}\ \overline{e'} \\ \Gamma, x_{ij} : T_j\ [\overline{\alpha} \mapsto \overline{T}]\ [\overline{p} \mapsto \overline{e}] \vdash_{P,Q} e_i : T\}\end{array}}{\Gamma \vdash_{P,Q} \mathsf{case}\ e\ \mathsf{of}\ \ |_i\ C_i\ \overline{x_i}\ \to\ e_i : T}$$

define unifyTypes

$$\frac{\Gamma \vdash_{P,Q} e_1 : T_x \qquad \langle P(x), T_x \rangle \models T'_x \qquad \Gamma, x : T'_x \vdash_{P,Q} e_2 : T}{\Gamma \vdash_{P,Q} \mathsf{let}\ x = e_1\ \mathsf{in}\ e_2 : T}$$

$$\frac{\Gamma \vdash \hat{T}_x \qquad \Gamma \vdash_{P,Q} e_1 : \hat{T}_x \qquad \left\langle P(x), \hat{T}_x \right\rangle \models \hat{T}'_x \qquad \Gamma, x : \hat{T}'_x \vdash_{P,Q} e_2 : \hat{T}}{\Gamma \vdash_{P,Q} \mathsf{letrec}\ x = e_1\ \mathsf{in}\ e_2 : \hat{T}}$$

$\boxed{\Gamma \vdash T_1 <: T_2}$

$$\frac{[\Gamma] \wedge [e_1] \Rightarrow [e_2]}{\Gamma \vdash \alpha^{e_1} <: \alpha^{e_2}}$$

$$\frac{\Gamma \vdash T_{x_2} <: T_{x_1} \qquad \Gamma, x_2 : T_{x_2} \vdash T_1\ [x_1 \mapsto x_2] <: T_2}{\Gamma \vdash x_1{:}T_{x_1} \to T_1 <: x_2{:}T_{x_2} \to T_2}$$

$$\frac{\Gamma \vdash T_1 <: T_2}{\Gamma \vdash \forall \alpha . T_1 <: \forall \alpha . T_2}$$

$$\frac{[\Gamma] \wedge [e_1] \Rightarrow [e_2] \qquad \forall i . \Gamma \vdash T_{1_i} <: T_{2_i} \qquad \forall j . [\Gamma] \wedge [e_{1_j}] \Rightarrow [e_{2_j}]}{\Gamma \vdash \mathsf{C}^{e_1}\ \overline{T_1}\ \overline{e_1} <: \mathsf{C}^{e_2}\ \overline{T_2}\ \overline{e_2}}$$

no subtype for tforallPr!
no subtype for tclass!

$\boxed{\Gamma \vdash T}$

$$\frac{\Gamma, v : \mathrm{shape}\,(T) \vdash e : \mathrm{bool}}{\Gamma \vdash \alpha^e}$$

$$\frac{\Gamma \vdash T_x \qquad \Gamma, x : T_x \vdash T}{\Gamma \vdash x{:}T_x \to T}$$

$$\frac{\Gamma \vdash T}{\Gamma \vdash \forall \alpha . T}$$

define tyConP

$$\frac{\Gamma, v : \mathrm{shape}\,(T) \vdash e : \mathrm{bool} \qquad \forall i . \Gamma \vdash T_i \qquad \overline{p} = \mathrm{predicates}\,(\mathsf{C}) \qquad \forall j . \Gamma, p_j \vdash e_j}{\Gamma \vdash \mathsf{C}^e\ \overline{T}\ \overline{e}}$$

no subtype for tforallPr!
no subtype for tclass!

$$\boxed{\Gamma, p \vdash e}$$

$$\frac{\Gamma, v : \tau, \overline{x : \tau} \vdash e : \mathrm{bool}}{\Gamma, p : \tau\, \langle \overline{x : \tau} \rangle \vdash e}$$