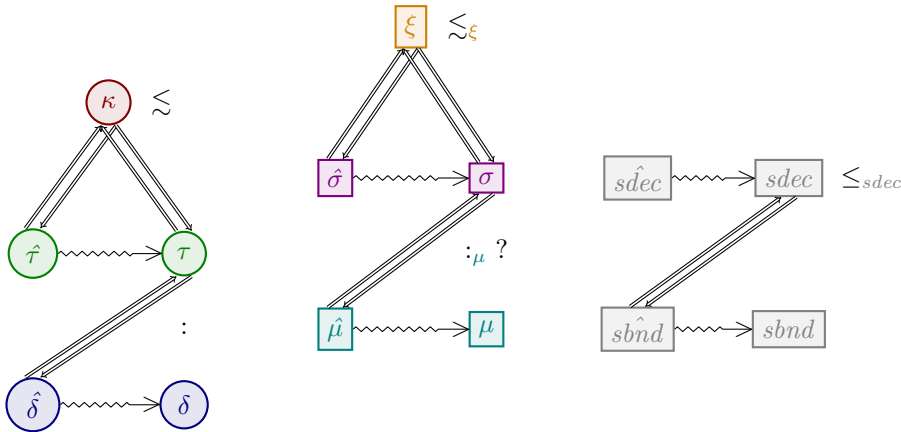# Hazel PHI: 10-modules

July 1, 2021

prerequisites

- Hazel PHI: 9-type-aliases-redux

  - github
  - current commit: 4410cd565ce717707e580e44f64868d3175fe2a6

- (optional) Hazel PHI: 1-labeled-tuples

  - github
  - current commit: 0a7d0b53ee7286d03ea3be13a7ac91a86f1c90b1

how to read

notes

external typ/sig/mod syntax not written out yet (waiting for construction dust to settle); patterns not handled yet– will be left till end.

syntax

$$
\begin{array}{llll}
\text{kind} & \kappa & ::= & \texttt{Type} & \text{kind of types} \\
& & | & \texttt{S}(\tau) & \text{singleton kind} \\
& & | & \texttt{KHole} & \text{kind hole} \\
& & | & \Pi_{t::\kappa_1}.\kappa_2 & \text{dependent function kind}
\end{array}
$$

HTyp	τ	::=	t	type variable
		|	bse	base type
		|	$\tau_1 \oplus \tau_2$	type binop
		|	$[\tau]$	list type
		|	$\lambda t{::}\kappa.\tau$	type function
		|	$\tau_1\ \tau_2$	type application
		|	$\{lab_1 \hookrightarrow \tau_1, ...\ lab_n \hookrightarrow \tau_n\}$	labelled product type (record)
		|	$\mu.lab$	module type projection
		|	$(\!()\!)$	empty type hole
		|	$(\!(\tau)\!)$	nonempty type hole
base type	bse	::=	`Int`	
		|	`Float`	
		|	`Bool`	
HTyp BinOp	$\oplus$	::=	$\times$	
		|	$+$	
		|	$\rightarrow$	
external expression	$\hat{\delta}$	::=	...	
		|	x	
		|	`signature` $s = \hat{\sigma}$ `in` $\hat{\delta}$	
		|	`module` $m = \hat{\mu}$ `in` $\hat{\delta}$	
		|	`module` $m{:}_\mu s = \hat{\mu}$ `in` $\hat{\delta}$	
		|	`functor something = something in` $\hat{\delta}$	
		|	$\hat{\mu}.lab$	module term projection
internal expression	δ	::=	...	
		|	x	
		|	`signature` $s = \sigma$ `in` δ	
		|	`module` $m{:}_\mu s = \mu$ `in` δ	
		|	`functor something = something in` δ	
		|	$\mu.lab$	module term projection
signature kind	ξ	::=	`SSigKind`(σ)	
		|	`SigKHole`	
external signature	$\hat{\sigma}$	::=	s	signature variable
		|	$\{sd\hat{e}cs\}$	structure signature
		|	$\Pi_{m:_\mu\hat{\sigma_1}}.\hat{\sigma_2}$	functor signature
		|	$(\!()\!)^{\tt u}$	empty signature hole
		|	$(\!(s)\!)^{\tt u}$	nonempty signature hole
signature	σ	::=	s	signature variable
		|	$\{sdecs\}$	structure signature
		|	$\Pi_{m:_\mu\sigma_1}.\sigma_2$	functor signature
		|	$(\!()\!)^{\tt u}$	empty signature hole
		|	$(\!(s)\!)^{\tt u}$	nonempty signature hole
		|	$\underset{\sim}{s}$	unbound signature variable
module	μ	::=	m	module variable
		|	$\{sbnds\}$	structure
		|	$\lambda m{:}_\mu\sigma.\mu$	functor
		|	$\mu_1\ \mu_2$	functor application
		|	$\mu.lab$	submodule projection
		|	$(\!()\!)$	empty module hole
		|	$(\!(\mu)\!)$	nonempty module hole
signature declarations	$sdecs$	::=	$\cdot$	
		|	$sdec, sdecs$	
signature declaration	$sdec$	::=	`type` $lab{::}\kappa$	
		|	`val` $lab{:}\tau$	
		|	`module` $lab{:}_\mu\sigma$	
		|	`functor` $lab{:}_\mu\sigma$	
structure bindings	$sbnds$	::=	$\cdot$	

$$\begin{array}{rcl} & | & sbnd, sbnds \\ \text{structure binding} \quad sbnd & ::= & \texttt{type } t = \tau \\ & | & \texttt{let } x{:}\tau = \delta \\ & | & \texttt{module } m = \mu \\ & | & \texttt{module } m{:}_\mu s = \mu \\ & | & \texttt{functor } m{:}_\mu s = \mu \end{array}$$

context definitions

$$\Delta, ?; \Gamma, x{:}\tau; \Phi, t{::}\kappa; \Xi, m{:}_\mu\sigma; \Psi, s{::}_\sigma\xi$$

declarative statics

scratch

$\boxed{\Delta; \Phi \vdash \kappa_1 \lesssim \kappa_2}$ κ_1 is a consistent subkind of κ_2

$$\begin{array}{c} \texttt{KCSubsumption} \\ \dfrac{test}{test} \end{array}$$

$\boxed{\Delta; \Phi; \Xi; \Psi \vdash \xi_1 \lesssim_\xi \xi_2}$ ξ_1 is a consistent sub signature kind of ξ_2

$$\begin{array}{c} \texttt{nameMe} \\ \exists sdec_x \in sdecs_1 \;\; st \;\; \Delta; \Phi; \Xi; \Psi \vdash \mathtt{SSigKind}(\{sdec_x\}) \lesssim_\xi \mathtt{SSigKind}(\{sdec_2\}) \\ \Delta; \Phi, \mathsf{type}(\Delta; \Phi; \Xi; \Psi, sdec_2); \Xi, \mathsf{submodule}(sdec_2); \Psi \vdash \{sdecs_1\} \lesssim_\xi \{sdecs_2\} \\ \hline \Delta; \Phi; \Xi; \Psi \vdash \mathtt{SSigKind}(\{sdec_{11}, sdec_{12}, sdecs_{13} \texttt{ as } sdecs_1\}) \lesssim_\xi \mathtt{SSigKind}(\{sdec_2, sdecs_2\}) \end{array}$$

$$\begin{array}{c} \texttt{single} \\ \dfrac{\Delta; \Phi; \Xi; \Psi \vdash sdec_1 \leq_{sdec} sdec_2}{\Delta; \Phi; \Xi; \Psi \vdash \mathtt{SSigKind}(\{sdec_1\}) \lesssim_\xi \mathtt{SSigKind}(\{sdec_2\})} \end{array} \qquad \begin{array}{c} \texttt{nil} \\ \dfrac{}{\Delta; \Phi; \Xi; \Psi \vdash \mathtt{SSigKind}(\{sdecs\}) \lesssim_\xi \mathtt{SSigKind}(\{\cdot\})} \end{array}$$

$$\begin{array}{c} \texttt{varprop} \\ \dfrac{s{::}_\sigma\xi \in \Psi}{\Delta; \Phi; \Xi; \Psi \vdash \mathtt{SSigKind}(s) \lesssim_\xi \xi} \end{array} \qquad \begin{array}{c} \texttt{nameMe?delete?} \\ \dfrac{\sigma_1 \neq s \qquad \Delta; \Phi; \Xi; \Psi \vdash \sigma_1 \Leftarrow \mathtt{SSigKind}(\sigma_2)}{\Delta; \Phi; \Xi; \Psi \vdash \mathtt{SSigKind}(\sigma_1) \lesssim_\xi \mathtt{SSigKind}(\sigma_2)} \end{array}$$

$$\begin{array}{c} \texttt{funct} \\ \dfrac{\Delta; \Phi; \Xi; \Psi \vdash \mathtt{SSigKind}(\sigma_{21}) \lesssim_\xi \mathtt{SSigKind}(\sigma_{11}) \qquad \Delta; \Phi; \Xi, m{:}_\mu\sigma_{11}; \Psi \vdash \mathtt{SSigKind}(\sigma_{12}) \lesssim_\xi \mathtt{SSigKind}(\sigma_{22})}{\Delta; \Phi; \Xi; \Psi \vdash \mathtt{SSigKind}(\Pi_{m{:}_\mu\sigma_{11}}.\sigma_{12}) \lesssim_\xi \mathtt{SSigKind}(\Pi_{m{:}_\mu\sigma_{21}}.\sigma_{22})} \end{array}$$

$$\begin{array}{c} \texttt{holes} \\ \dfrac{\Delta; \Phi; \Xi; \Psi \vdash (\!|\!|)^{\mathtt{u}} \Leftarrow \xi}{\Delta; \Phi; \Xi; \Psi \vdash \mathtt{SSigKind}((\!|\!|)^{\mathtt{u}}) \lesssim_\xi \xi} \end{array} \quad \begin{array}{c} \texttt{neholes} \\ \dfrac{\Delta; \Phi; \Xi; \Psi \vdash (\!|s|\!)^{\mathtt{u}} \Leftarrow \xi}{\Delta; \Phi; \Xi; \Psi \vdash \mathtt{SSigKind}((\!|s|\!)^{\mathtt{u}}) \lesssim_\xi \xi} \end{array} \quad \begin{array}{c} \texttt{CSubSigKindHoleL} \\ \dfrac{}{\Delta; \Phi; \Xi; \Psi \vdash \mathtt{SigKHole} \lesssim_\xi \xi} \end{array}$$

$$\begin{array}{c} \texttt{CSubSigKindHoleR} \\ \dfrac{}{\Delta; \Phi; \Xi; \Psi \vdash \xi \lesssim_\xi \mathtt{SigKHole}} \end{array}$$

$\boxed{\Delta; \Phi; \Xi; \Psi \vdash \sigma \Rightarrow \xi}$ σ synthesizes signature kind ξ

$$\begin{array}{c} \texttt{SynSigKndVar} \\ \dfrac{s{::}_\sigma\xi \in \Psi}{\Delta; \Phi; \Xi; \Psi \vdash s \Rightarrow \mathtt{SSigKind}(s)} \end{array} \qquad \begin{array}{c} \texttt{SynSigKndVarFail} \\ \dfrac{s \notin \mathsf{dom}(\Psi)}{\Delta; \Phi; \Xi; \Psi \vdash s \Rightarrow \mathtt{SigKHole}} \end{array} \qquad \dfrac{\{sdecs\} wellformed?}{\vdash \{sdecs\} \Rightarrow \mathtt{SSigKind}(\{sdecs\})}$$

$$\dfrac{\Delta; \Phi; \Xi, m{:}_\mu\sigma_1; \Psi \vdash \sigma_2 \Rightarrow \xi}{\Delta; \Phi; \Xi; \Psi \vdash \Pi_{m{:}_\mu\sigma_1}.\sigma_2 \Rightarrow \mathtt{SSigKind}(\Pi_{m{:}_\mu\sigma_1}.\sigma_2)} \qquad \begin{array}{c} \texttt{SynSigKndSigHole} \\ \dfrac{u{::}_\sigma\xi \in \Delta}{\Delta; \Phi; \Xi; \Psi \vdash (\!|\!|)^{\mathtt{u}} \Rightarrow \xi} \end{array} \qquad \begin{array}{c} \texttt{SynSigKndSigHole} \\ \dfrac{u{::}_\sigma\xi \in \Delta \qquad \Delta; \Phi; \Xi; \Psi \vdash s \Rightarrow \xi_1}{\Delta; \Phi; \Xi; \Psi \vdash (\!|s|\!)^{\mathtt{u}} \Rightarrow \xi} \end{array}$$

$\boxed{\Delta; \Phi; \Xi; \Psi \vdash \sigma \Leftarrow \xi}$ σ analyzes against signature kind ξ

Sub
$$\dfrac{\Delta; \Phi; \Xi; \Psi \vdash \sigma \Rightarrow \xi_1 \qquad \Delta; \Phi; \Xi; \Psi \vdash \xi_1 \lesssim_\xi \xi}{\Delta; \Phi; \Xi; \Psi \vdash \sigma \Leftarrow \xi}$$

$\boxed{\Delta; \Phi; \Xi; \Psi \vdash sdec_1 \leq_{sdec} sdec_2}$ $sdec_1$ is a subsdec of $sdec_2$

singleType
$$\dfrac{\vdash \kappa_1 \lesssim \kappa_2}{\Delta; \Phi; \Xi; \Psi \vdash \text{type } lab{::}\kappa_1 \leq_{sdec} \text{type } lab{::}\kappa_2}$$

singleVa
$$\dfrac{\Delta; \Phi; \Xi; \Psi \vdash \tau_1 \equiv \tau_2}{\Delta; \Phi; \Xi; \Psi \vdash \text{val } lab{:}\tau_1 \leq_{sdec} \text{val } lab{:}\tau_2}$$

singleMod
$$\dfrac{\Delta; \Phi; \Xi; \Psi \vdash \sigma_1 \Leftarrow \text{SSigKind}(\sigma_2)}{\Delta; \Phi; \Xi; \Psi \vdash \text{module } lab{:}_\mu\sigma_1 \leq_{sdec} \text{module } lab{:}_\mu\sigma_2}$$

elaboration

$\boxed{\Gamma; \Phi; \Xi \vdash \hat{\delta} \Rightarrow \tau \rightsquigarrow \delta \dashv \Delta}$ $\hat{\delta}$ synthesizes type τ and elaborates to δ with hole context Δ

$\cdots$

SynElabLetMod
$$\dfrac{\Gamma; \Phi; \Xi \vdash \hat{\mu} \Rightarrow \sigma \rightsquigarrow \mu \dashv \Delta_1 \qquad \Gamma; \Phi; \Xi, m{:}_\mu\sigma \vdash \hat{\delta} \Rightarrow \tau \rightsquigarrow \delta \dashv \Delta_2}{\Gamma; \Phi; \Xi \vdash \text{module } m = \hat{\mu} \text{ in } \hat{\delta} \Rightarrow \tau \rightsquigarrow \text{module } m = \mu \text{ in } \delta \dashv \Delta_1 \cup \Delta_2}$$

SynElabLetModAnn
$$\dfrac{\Phi; \Xi \vdash \hat{\sigma} \Rightarrow \xi \rightsquigarrow \sigma \dashv \Delta_1 \qquad \Gamma; \Phi; \Xi \vdash \hat{\mu} \Leftarrow \sigma \rightsquigarrow \mu \dashv \Delta_2 \qquad \Gamma; \Phi; \Xi, m{:}_\mu\sigma \vdash \hat{\delta} \Rightarrow \tau \rightsquigarrow \delta \dashv \Delta_3}{\Gamma; \Phi; \Xi \vdash \text{module } m{:}_\mu\hat{\sigma} = \hat{\mu} \text{ in } \hat{\delta} \Rightarrow \tau \rightsquigarrow \text{module } m{:}_\mu\sigma = \mu \text{ in } \delta \dashv \Delta_1 \cup \Delta_2 \cup \Delta_3}$$

SynElabModTermPrj
$$\dfrac{\Gamma; \Phi; \Xi \vdash \hat{\mu} \Rightarrow \sigma \rightsquigarrow \mu \dashv \Delta \qquad \Phi; \Xi \vdash \sigma \Rightarrow \xi}{\Gamma; \Phi; \Xi \vdash \hat{\mu}.lab \Rightarrow \tau \rightsquigarrow \mu.lab \dashv \Delta}$$

$\boxed{\Phi; \Xi \vdash \hat{\tau} \Rightarrow \kappa \rightsquigarrow \tau \dashv \Delta}$ $\hat{\tau}$ synthesizes kind κ and elaborates to τ with hole context Δ

$\cdots$

SynElabModTypPrj
$$\dfrac{\Phi; \Xi \vdash m \Rightarrow \sigma \rightsquigarrow m \dashv \Delta \qquad \textit{something}\sigma\kappa}{\Phi; \Xi \vdash m.lab \Rightarrow \kappa \rightsquigarrow m.lab \dashv \Delta}$$

$\boxed{\Phi; \Xi \vdash \hat{\tau} \Leftarrow \kappa \rightsquigarrow \tau \dashv \Delta}$ $\hat{\tau}$ analyzes against kind κ and elaborates to τ with hole context Δ

$\boxed{\Gamma; \Phi; \Xi \vdash \hat{\mu} \Rightarrow \sigma \rightsquigarrow \mu \dashv \Delta}$ $\hat{\mu}$ synthesizes signature σ and elaborates to μ with hole context Δ

SynElabModVar
$$\dfrac{m{:}_\mu\sigma \in \Xi}{\Gamma; \Phi; \Xi \vdash m \Rightarrow \sigma \rightsquigarrow m \dashv \cdot}$$

SynElabModVarFail
$$\dfrac{m \notin \text{dom}(\Xi)}{\Gamma; \Phi; \Xi \vdash m \Rightarrow (\!|\,|\!) \rightsquigarrow (\!|m|\!)^{\mathtt{u}} \dashv u{:}_\mu(\!|\,|\!)}$$

SynElabConsStruct
$$\dfrac{\Gamma; \Phi; \Xi \vdash \hat{sbnd} \Rightarrow sdec \rightsquigarrow sbnd \dashv \Delta_1 \qquad \Gamma, \text{val}(sdec); \Phi, \text{type}(\Delta_1; \Phi; \Xi; \Psi, sdec); \Xi, \text{submodule}(sdec) \vdash \{\hat{sbnds}\} \Rightarrow \{sdecs\} \rightsquigarrow \{sbnds\} \dashv \Delta_2}{\Gamma; \Phi; \Xi \vdash \{\hat{sbnd}, \hat{sbnds}\} \Rightarrow \{sdec, sdecs\} \rightsquigarrow \{sbnd, sbnds\} \dashv \Delta_1 \cup \Delta_2}$$

SynElabNilStruct
$$\dfrac{}{\Gamma; \Phi; \Xi \vdash \{\cdot\} \Rightarrow \{\cdot\} \rightsquigarrow \{\cdot\} \dashv \cdot}$$

SynElabEmptyModHole
$$\dfrac{}{\Gamma; \Phi; \Xi \vdash (\!|\,|\!)^{\mathtt{u}} \Rightarrow (\!|\,|\!) \rightsquigarrow (\!|\,|\!)^{\mathtt{u}} \dashv u{:}_\mu(\!|\,|\!)}$$

SynElabNonemptyModHole
$$\dfrac{}{\Gamma; \Phi; \Xi \vdash (\!|m|\!)^{\mathtt{u}} \Rightarrow (\!|\,|\!) \rightsquigarrow (\!|m|\!)^{\mathtt{u}} \dashv u{:}_\mu(\!|\,|\!)}$$

functor stuff

$\boxed{\Gamma; \Phi; \Xi \vdash \hat{\mu} \;\Leftarrow\; \sigma \leadsto \mu \dashv \Delta}$ $\hat{\mu}$ analyzes against signature σ and elaborates to μ with hole context Δ

AnaElabModSubsumption
$$\frac{\Gamma; \Phi; \Xi \vdash \hat{\mu} \;\Rightarrow\; \sigma \leadsto \mu \dashv \Delta}{\Gamma; \Phi; \Xi \vdash \hat{\mu} \;\Leftarrow\; \sigma \leadsto \mu \dashv \Delta}$$

$\boxed{\Gamma; \Phi; \Xi \vdash \hat{sbnd} \;\Rightarrow\; sdec \leadsto sbnd \dashv \Delta}$ $\hat{sbnd}$ synthesizes declaration $sdec$ and elaborates to $sbnd$ with hole context Δ

SynElabTypeSbnd
$$\frac{\Phi; \Xi \vdash \hat{\tau} \;\Rightarrow\; \kappa \leadsto \tau \dashv \Delta}{\Gamma; \Phi; \Xi \vdash \mathtt{type}\ t = \hat{\tau} \;\Rightarrow\; \mathtt{type}\ t{::}\kappa \leadsto \mathtt{type}\ t = \tau \dashv \Delta}$$

SynElabValSbnd
$$\frac{\Phi; \Xi \vdash \hat{\tau} \;\Rightarrow\; \kappa \leadsto \tau \dashv \Delta_1 \qquad \Gamma; \Phi; \Xi \vdash \hat{\delta} \;\Leftarrow\; \tau \leadsto \delta \dashv \Delta_2}{\Gamma; \Phi; \Xi \vdash \mathtt{let}\ x{:}\hat{\tau} = \hat{\delta} \;\Rightarrow\; \mathtt{val}\ x{:}\tau \leadsto \mathtt{let}\ x{:}\tau = \delta \dashv \Delta_1 \cup \Delta_2}$$

SynElabModSbnd
$$\frac{\Gamma; \Phi; \Xi \vdash \hat{\mu} \;\Rightarrow\; \sigma \leadsto \mu \dashv \Delta}{\Gamma; \Phi; \Xi \vdash \mathtt{module}\ m = \hat{\mu} \;\Rightarrow\; \mathtt{module}\ m{:}_\mu\sigma \leadsto \mathtt{module}\ m{:}_\mu\sigma = \mu \dashv \Delta}$$

SynElabModAnnSbnd
$$\frac{\Phi; \Xi \vdash \hat{\sigma} \;\Rightarrow\; \xi \leadsto \sigma_1 \dashv \Delta_1 \qquad \Gamma; \Phi; \Xi \vdash \hat{\mu} \;\Rightarrow\; \sigma_2 \leadsto \mu \dashv \Delta_2 \qquad \Phi; \Xi; \Psi \vdash \sigma_2 \;\Leftarrow\; \xi}{\Gamma; \Phi; \Xi \vdash \mathtt{module}\ m{:}_\mu\hat{\sigma} = \hat{\mu} \;\Rightarrow\; \mathtt{module}\ m{:}_\mu\sigma_1 \leadsto \mathtt{module}\ m{:}_\mu\sigma_1 = \mu \dashv \Delta_1 \cup \Delta_2}$$

$\boxed{\Gamma; \Phi; \Xi \vdash \hat{sbnd} \;\Leftarrow\; sdec \leadsto sbnd \dashv \Delta}$ $\hat{sbnd}$ analyzes against declaration $sdec$ and elaborates to $sbnd$ with hole context Δ

subsump
$$\frac{\Gamma; \Phi; \Xi; l\Psi \vdash \hat{sbnd} \;\Rightarrow\; sdec_1 \leadsto sbnd \dashv \Delta \qquad \Delta; \Phi; \Xi; \Psi \vdash sdec_1 \leq_{sdec} sdec}{\Gamma; \Phi; \Xi; \Psi \vdash \hat{sbnd} \;\Leftarrow\; sdec \leadsto sbnd \dashv \Delta}$$

$\boxed{\Gamma; \Phi; \Xi; \Psi \vdash \hat{sdec} \leadsto sdec \dashv \Delta}$ $\hat{sdec}$ elaborates to $sdec$ with hole context Δ

opq
$$\frac{}{\Gamma; \Phi; \Xi; \Psi \vdash \mathtt{type}\ lab \leadsto \mathtt{type}\ lab{::}\mathtt{Type} \dashv \cdot}$$

trn
$$\frac{\Gamma; \Phi; \Xi; \Psi \vdash \hat{\tau} \;\Rightarrow\; \kappa \leadsto \tau \dashv \Delta}{\Gamma; \Phi; \Xi; \Psi \vdash \mathtt{type}\ lab{::}\hat{\tau} \leadsto \mathtt{type}\ lab{::}\kappa \dashv \Delta}$$

val
$$\frac{\Gamma; \Phi; \Xi; \Psi \vdash \hat{\tau} \;\Rightarrow\; \kappa \leadsto \tau \dashv \Delta}{\Gamma; \Phi; \Xi; \Psi \vdash \mathtt{val}\ lab{:}\hat{\tau} \leadsto \mathtt{val}\ lab{:}\tau \dashv \Delta}$$

mod
$$\frac{\Gamma; \Phi; \Xi; \Psi \vdash \hat{\sigma} \;\Rightarrow\; \xi \leadsto \sigma \dashv \Delta}{\Gamma; \Phi; \Xi; \Psi \vdash \mathtt{module}\ lab{:}_\mu\hat{\sigma} \leadsto \mathtt{module}\ lab{:}_\mu\sigma \dashv \Delta}$$

`we're going to need HOFunctors so we don't need to preclude users from typing a functor into a module and vice versa`

$\boxed{\Phi; \Xi; \Psi \vdash \hat{\sigma} \;\Rightarrow\; \xi \leadsto \sigma \dashv \Delta}$ $\hat{\sigma}$ synthesizes signature kind ξ and elaborates to σ with hole context Δ

SynSigEmptyHole
$$\frac{}{\Phi; \Xi; \Psi \vdash (\!|\,|\!)^{\mathtt{u}} \;\Rightarrow\; \mathtt{SigKHole} \leadsto (\!|\,|\!)^{\mathtt{u}} \dashv u{::}_\sigma\mathtt{SigKHole}}$$

SynSigNonEmptyHole

$\boxed{\Phi; \Xi \vdash \hat{\sigma} \;\Leftarrow\; \xi \leadsto \sigma \dashv \Delta}$ $\hat{\sigma}$ analyzes against signature kind ξ and elaborates to σ with hole context Δ

misc functions

$$\mathsf{val}(sdec) = \begin{cases} lab{:}\tau & sdec = \mathtt{val}\ lab{:}\tau \\ \cdot & \text{otherwise} \end{cases}$$

$$\mathsf{type}(cntxts, sdec) = \begin{cases} lab{::}\kappa & sdec = \mathtt{type}\ lab{::}\kappa \\ \cdot & \text{otherwise} \end{cases}$$

$$\mathsf{submodule}(sdec) = \begin{cases} lab{:}_\mu\sigma & sdec = \mathtt{module}\ lab{:}_\mu\sigma \\ \cdot & \text{otherwise} \end{cases}$$

$$\mathtt{S_{Type}}(\tau) := \mathtt{S}(\tau)$$
$$\mathtt{S_{S(\tau_1)}}(\tau) := \mathtt{S}(\tau)$$
$$\mathtt{S_{KHole}}(\tau) := \mathtt{KHole}$$

theorems

Kind Synthesis Precision

If $\text{cntxts} \vdash \tau \Rightarrow \kappa$ then $\forall \kappa_1.\text{cntxts} \vdash \tau::\kappa_1 \implies \text{cntxts} \vdash \kappa \lesssim \kappa_1$