Hazel PHI: 10-modules

July 2, 2021

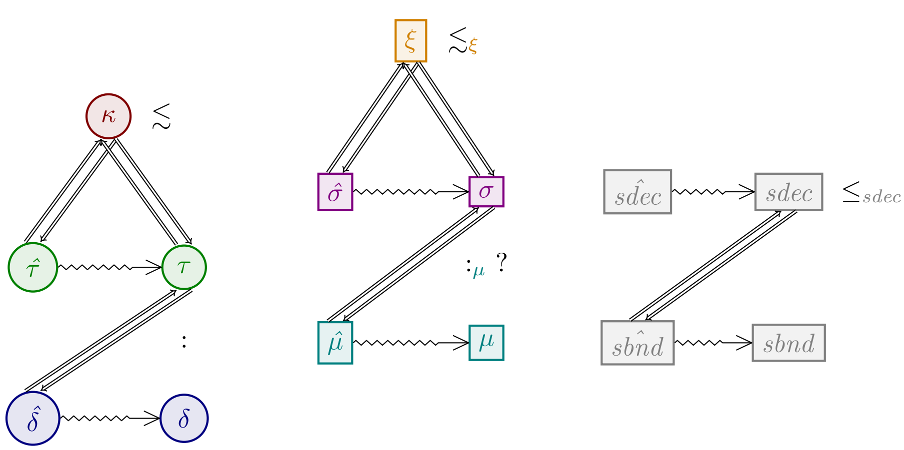
prerequisites

- Hazel PHI: 9-type-aliases-redux
  - github
  - current commit: 4410cd565ce717707e580e44f64868d3175fe2a6
- (optional) Hazel PHI: 1-labeled-tuples
  - github
  - current commit: 0a7d0b53ee7286d03ea3be13a7ac91a86f1c90b1

how to read

800000	kinds	D08000	signature kind
008000	types (constructors)	800080	signatures
000080	terms	008080	modules

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

kind	κ	::=	$\mathtt{Type}$	kind of types
		|	$\mathtt{S}(\tau)$	singleton kind
		|	$\mathtt{KHole}$	kind hole
		|	$\Pi_{t::\kappa_1}.\kappa_2$	dependent function kind

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
		$\|$	$\{lab_1 \hookrightarrow \tau_1, \ldots\ lab_n \hookrightarrow \tau_n\}$	labelled product type (record)
		$\|$	$\mu.lab$	module type projection
		$\|$	$(\!\|\,\|\!)$	empty type hole
		$\|$	$(\!\|\tau\|\!)$	nonempty type hole
base type	bse	$::=$	$\mathtt{Int}$	
		$\|$	$\mathtt{Float}$	
		$\|$	$\mathtt{Bool}$	
HTyp BinOp	$\oplus$	$::=$	$\times$	
		$\|$	$+$	
		$\|$	$\rightarrow$	
external expression	$\hat{\delta}$	$::=$	$\ldots$	
		$\|$	x	
		$\|$	$\mathtt{signature}\ s = \hat{\sigma}\ \mathtt{in}\ \hat{\delta}$	
		$\|$	$\mathtt{module}\ m = \hat{\mu}\ \mathtt{in}\ \hat{\delta}$	
		$\|$	$\mathtt{module}\ m{:}_{\mu}s = \hat{\mu}\ \mathtt{in}\ \hat{\delta}$	
		$\|$	$\mathtt{functor\ something} = \mathtt{something}\ \mathtt{in}\ \hat{\delta}$	
		$\|$	$\hat{\mu}.lab$	module term projection
internal expression	δ	$::=$	$\ldots$	
		$\|$	x	
		$\|$	$\mathtt{signature}\ s = \sigma\ \mathtt{in}\ \delta$	
		$\|$	$\mathtt{module}\ m{:}_{\mu}s = \mu\ \mathtt{in}\ \delta$	
		$\|$	$\mathtt{functor\ something} = \mathtt{something}\ \mathtt{in}\ \delta$	
		$\|$	$\mu.lab$	module term projection
signature kind	ξ	$::=$	$\mathtt{SSigKind}(\sigma)$	
		$\|$	$\mathtt{SigKHole}$	
external signature	$\hat{\sigma}$	$::=$	s	signature variable
		$\|$	$\{\widehat{sdecs}\}$	structure signature
		$\|$	$\Pi_{m:_{\mu}\hat{\sigma_1}}.\hat{\sigma_2}$	functor signature
		$\|$	$(\!\|\,\|\!)^{\mathtt{u}}$	empty signature hole
		$\|$	$(\!\|s\|\!)^{\mathtt{u}}$	nonempty signature hole
signature	σ	$::=$	s	signature variable
		$\|$	$\{sdecs\}$	structure signature
		$\|$	$\Pi_{m:_{\mu}\sigma_1}.\sigma_2$	functor signature
		$\|$	$(\!\|\,\|\!)^{\mathtt{u}}$	empty signature hole
		$\|$	$(\!\|s\|\!)^{\mathtt{u}}$	nonempty signature hole
		$\|$	$\underset{\sim\sim}{s}$	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	$sdec$	$::=$	$\mathtt{type}\ lab{::}\kappa$	
		$\|$	$\mathtt{val}\ lab{:}\tau$	
		$\|$	$\mathtt{module}\ lab{:}_{\mu}\sigma$	
		$\|$	$\mathtt{functor}\ lab{:}_{\mu}\sigma$	
structure bindings	$sbnds$	$::=$	$\cdot$	

		$\mid$	$sbnd, sbnds$
structure binding	$sbnd$	$::=$	$\texttt{type}\ t = \tau$
		$\mid$	$\texttt{let}\ x{:}\tau = \delta$
		$\mid$	$\texttt{module}\ m = \mu$
		$\mid$	$\texttt{module}\ m{:}_{\mu} s = \mu$
		$\mid$	$\texttt{functor}\ m{:}_{\mu} s = \mu$

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

KCSubsumption
$$\frac{test}{test}$$

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

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

single
$$\frac{\Delta; \Phi; \Xi; \Psi \vdash sdec_1 \leq_{sdec} sdec_2}{\Delta; \Phi; \Xi; \Psi \vdash \texttt{SSigKind}(\{sdec_1\}) \lesssim_{\xi} \texttt{SSigKind}(\{sdec_2\})}$$

nil
$$\frac{}{\Delta; \Phi; \Xi; \Psi \vdash \texttt{SSigKind}(\{sdecs\}) \lesssim_{\xi} \texttt{SSigKind}(\{\cdot\})}$$

varprop
$$\frac{s{::}_{\sigma}\xi \in \Psi}{\Delta; \Phi; \Xi; \Psi \vdash \texttt{SSigKind}(s) \lesssim_{\xi} \xi}$$

nameMe?delete?
$$\frac{\sigma_1 \neq s \qquad \Delta; \Phi; \Xi; \Psi \vdash \sigma_1 \ \Leftarrow\ \texttt{SSigKind}(\sigma_2)}{\Delta; \Phi; \Xi; \Psi \vdash \texttt{SSigKind}(\sigma_1) \lesssim_{\xi} \texttt{SSigKind}(\sigma_2)}$$

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

holes
$$\frac{\Delta; \Phi; \Xi; \Psi \vdash (\!|\,|\!)^{\mathtt{u}} \ \Leftarrow\ \xi}{\Delta; \Phi; \Xi; \Psi \vdash \texttt{SSigKind}((\!|\,|\!)^{\mathtt{u}}) \lesssim_{\xi} \xi}$$

neholes
$$\frac{\Delta; \Phi; \Xi; \Psi \vdash (\!|\mathsf{s}|\!)^{\mathtt{u}} \ \Leftarrow\ \xi}{\Delta; \Phi; \Xi; \Psi \vdash \texttt{SSigKind}((\!|\mathsf{s}|\!)^{\mathtt{u}}) \lesssim_{\xi} \xi}$$

CSubSigKindHoleL
$$\frac{}{\Delta; \Phi; \Xi; \Psi \vdash \texttt{SigKHole} \lesssim_{\xi} \xi}$$

CSubSigKindHoleR
$$\frac{}{\Delta; \Phi; \Xi; \Psi \vdash \xi \lesssim_{\xi} \texttt{SigKHole}}$$

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

SynSigKndVar
$$\frac{s{::}_{\sigma}\xi \in \Psi}{\Delta; \Phi; \Xi; \Psi \vdash s \ \Rightarrow\ \texttt{SSigKind}(s)}$$

SynSigKndVarFail
$$\frac{s \notin \mathsf{dom}(\Psi)}{\Delta; \Phi; \Xi; \Psi \vdash s \ \Rightarrow\ \texttt{SigKHole}}$$

$$\frac{\{sdecs\} well formed?}{\vdash \{sdecs\} \ \Rightarrow\ \texttt{SSigKind}(\{sdecs\})}$$

$$\frac{\Delta; \Phi; \Xi, m{:}_{\mu}\sigma_1; \Psi \vdash \sigma_2 \ \Rightarrow\ \xi}{\Delta; \Phi; \Xi; \Psi \vdash \Pi_{m:_{\mu}\sigma_1}.\sigma_2 \ \Rightarrow\ \texttt{SSigKind}(\Pi_{m:_{\mu}\sigma_1}.\sigma_2)}$$

SynSigKndSigHole
$$\frac{u{::}_{\sigma}\xi \in \Delta}{\Delta; \Phi; \Xi; \Psi \vdash (\!|\,|\!)^{\mathtt{u}} \ \Rightarrow\ \xi}$$

SynSigKndSigHole
$$\frac{u{::}_{\sigma}\xi \in \Delta \qquad \Delta; \Phi; \Xi; \Psi \vdash s \ \Rightarrow\ \xi_1}{\Delta; \Phi; \Xi; \Psi \vdash (\!|s|\!)^{\mathtt{u}} \ \Rightarrow\ \xi}$$

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

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

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

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

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

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

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

$\cdots$

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

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

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

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

$\cdots$

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

$\boxed{\Phi;\Xi \vdash \hat{\tau} \Leftarrow \kappa \rightsquigarrow \tau \dashv \Delta}$ $\hat{\tau}$ 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

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

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

$$\frac{\begin{array}{c}\Gamma;\Phi;\Xi \vdash \hat{sbnd} \Rightarrow sdec \rightsquigarrow sbnd \dashv \Delta_1 \\ \Gamma, \mathsf{val}(sdec); \Phi, \mathsf{type}(\Delta_1;\Phi;\Xi;\Psi, sdec); \Xi, \mathsf{submodule}(sdec) \vdash \{\hat{sbnds}\} \Rightarrow \{sdecs\} \rightsquigarrow \{sbnds\} \dashv \Delta_2\end{array}}{\Gamma;\Phi;\Xi \vdash \{\hat{sbnd}, \hat{sbnds}\} \Rightarrow \{sdec, sdecs\} \rightsquigarrow \{sbnd, sbnds\} \dashv \Delta_1 \cup \Delta_2}\ \texttt{SynElabConsStruct}$$

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

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

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

`functor stuff`

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

SynSigNonEmptyHole

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

misc functions

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

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

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

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

theorems

Kind Synthesis Precision

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