Hazel PHI: 10-modules

June 17, 2021

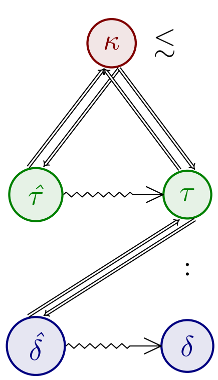
prerequisites

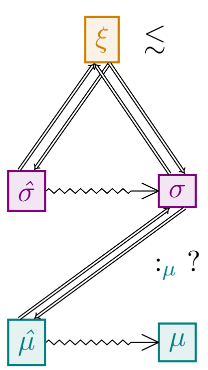
- Hazel PHI: 9-type-aliases-redux
  - github
  - current commit: 4410cd565ce717707e580e44f64868d3175fe2a6
- (optional) Hazel PHI: 1-labeled-tuples
  - github
  - current commit: 0a7d0b53ee7286d03ea3be13a7ac91a86f1c90b1

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
		$\mid$	$\mathtt{S}(\tau)$	singleton kind
		$\mid$	$\mathtt{KHole}$	kind hole
		$\mid$	$\Pi_{t::\kappa_1}.\kappa_2$	dependent function kind

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

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

contexts

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

statics

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

$$\texttt{KCSubsumption}\quad \frac{\mathit{test}}{\mathit{test}}$$

elab

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

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

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

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

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

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

$\boxed{\Phi; \Xi \vdash \hat{\tau} \Leftarrow \kappa \rightsquigarrow \tau \dashv \Delta}$ $\hat{\tau}$ 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
$$\frac{m{:}_{\mu}\sigma\in\Xi}{\Gamma;\Phi;\Xi\vdash m\ \Rightarrow\ \sigma\rightsquigarrow m\dashv\cdot}$$

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

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

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

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

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

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

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

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

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

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

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

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

`misc`

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

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

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