

GADTs Meet Their Match:

Pattern-Matching Warnings That Account for GADTs, Guards, and Laziness

SEBASTIAN GRAF, Karlsruhe Institute of Technology, Germany

SIMON PEYTON JONES, Microsoft Research, UK

Authors' addresses: Sebastian Graf, Karlsruhe Institute of Technology, Karlsruhe, Germany, sebastian.graf@kit.edu; Simon Peyton Jones, Microsoft Research, Cambridge, UK, simonpj@microsoft.com.

Guard Syntax

$K \in$	Con	$\gamma \in$	TyCt	$::=$	$\tau_1 \sim \tau_2 \mid \dots$
$x, y, a, b \in$	Var	$g \in$	Grd	$::=$	$\text{let } x : \tau = e$
$\tau, \sigma \in$	Type				$\mid K \bar{a} \bar{\gamma} \bar{y} : \bar{\tau} \leftarrow x$
$e \in$	Expr	$::=$	$x : \tau$		$\mid !x$
			$\mid K \bar{a} \bar{\gamma} \bar{e} : \bar{\tau}$		
			$\mid \dots$		

DNF Syntax

Γ	$::=$	$\emptyset \mid \Gamma, x : \tau \mid \Gamma, a$	Context
δ	$::=$	$\gamma \mid K \bar{x} : \bar{\tau} \leftarrow \bar{y} \mid x \neq K \mid x \approx \perp \mid x \neq \perp \mid x \approx e$	Literals
Δ	$::=$	$\checkmark \mid \Delta \wedge \delta$	Clause
∇	$::=$	$\times \mid \Delta \mid \nabla_1 \vee \nabla_2$	Formula
		$\times \oplus \delta = \times$	
		$\Delta \oplus \delta = \Delta \wedge \delta$	
		$\nabla_1 \vee \nabla_2 \oplus \delta = (\nabla_1 \oplus \delta) \vee (\nabla_2 \oplus \delta)$	

Clause Tree Syntax

$\mathcal{T}[r]$	$::=$	Rhs \mid Many \bar{r}
$t_G \in \text{Gdt}$	$::=$	$\mathcal{T}[t_G] \mid$ Guard $g \ t_G$
$t_A \in \text{Ant}$	$::=$	$\mathcal{T}[t_A] \mid$ MayDiverge $t_A \mid$ Inaccessible t_A

Checking Guard Trees

$$\boxed{\mathcal{U}(\nabla, \text{Gdt}) = \nabla}$$

$\mathcal{U}(\nabla, \text{Rhs})$	$=$	\times
$\mathcal{U}(\nabla, \text{Many } \bar{t})$	$=$	$\mathcal{U}(\dots \mathcal{U}(\mathcal{U}(\nabla, t_1), t_2) \dots, t_n)$
$\mathcal{U}(\nabla, \text{Guard } (!x) \ t)$	$=$	$\mathcal{U}(\nabla \oplus (x \neq \perp), t)$
$\mathcal{U}(\nabla, \text{Guard } (\text{let } x = e) \ t)$	$=$	$\mathcal{U}(\nabla \oplus (x \approx e), t)$
$\mathcal{U}(\nabla, \text{Guard } (K \bar{a} \bar{\gamma} \bar{y} : \bar{\tau} \leftarrow x) \ t)$	$=$	$(\nabla \oplus (x \neq K) \oplus (x \neq \perp)) \cup \mathcal{U}(\nabla \oplus (K \bar{y} : \bar{\tau} \leftarrow x) \oplus \bar{\gamma}, gs)$

$$\boxed{\mathcal{A}_\Gamma(\nabla, \text{Gdt}) = \text{Ant}}$$

$\mathcal{A}_\Gamma(\nabla, \text{Rhs})$	$=$	$\begin{cases} \text{Inaccessible Rhs,} & \mathcal{V}(\Gamma, \nabla) = \emptyset \\ \text{Rhs,} & \text{otherwise} \end{cases}$
$\mathcal{A}_\Gamma(\nabla, \text{Many } \bar{t})$	$=$	Many $(\mathcal{A}_\Gamma(\nabla'_0, t_1), \dots, \mathcal{A}_\Gamma(\nabla'_{n-1}, t_n))$ where $\begin{cases} \nabla'_0 & = \nabla \\ \nabla'_{n+1} & = \mathcal{U}(\nabla'_n, t_{n+1}) \end{cases}$
$\mathcal{A}_\Gamma(\nabla, \text{Guard } (!x) \ t)$	$=$	$\mathcal{D}(\nabla, \mathcal{A}_\Gamma(\nabla \oplus (x \neq \perp), t))$
$\mathcal{A}_\Gamma(\nabla, \text{Guard } (\text{let } x = e) \ t)$	$=$	$\mathcal{A}_\Gamma(\nabla \oplus (x \approx e), t)$
$\mathcal{A}_\Gamma(\nabla, \text{Guard } (K \bar{a} \bar{\gamma} \bar{y} : \bar{\tau} \leftarrow x) \ t)$	$=$	$\mathcal{D}(\nabla, \mathcal{A}_\Gamma(\nabla \oplus (K \bar{y} : \bar{\tau} \leftarrow x) \oplus \bar{\gamma}, t))$

$$\boxed{\mathcal{D}(\nabla, \text{Ant}) = \text{Ant}}$$

$$\mathcal{D}(\nabla, t) = \begin{cases} t, & \mathcal{V}(\Gamma, \nabla \oplus (x \approx \perp)) = \emptyset \\ \text{MayDiverge } t & \text{otherwise} \end{cases}$$

$$\boxed{\mathcal{V}(\Gamma, \nabla) = \text{values}}$$

TBD: Oracle implementation. This is provideEvidence

Putting it all together

- (0) Input: Context with match vars Γ and desugared Gdt t
- (1) Report n value vectors of $\mathcal{V}(\Gamma, \mathcal{U}(\checkmark, t))$ as uncovered
- (2) Report the collected redundant and not-redundant-but-inaccessible clauses in $\mathcal{A}_\Gamma(\checkmark, t)$ (TODO: Write a function that collects the RHSs, maybe add numbers to Rhs to distinguish).

This figure is completely out of date, don't waste your time

Test if Oracle state Delta is unsatisfiable

$$\frac{\boxed{\not\vdash_{\text{SAT}} \Gamma \vdash \Delta} \quad \not\vdash_{\text{SAT}} \Gamma \vdash f\text{us}\Gamma \triangleright \Delta}{\not\vdash_{\text{SAT}} \Gamma \vdash \Delta}$$

Test a list of SAT roots for inhabitants

$$\frac{\boxed{\not\vdash_{\text{SAT}} \Gamma \vdash \bar{x} \triangleright \Delta} \quad \not\vdash_{\text{SAT}} \Gamma \vdash x_i \triangleright \Delta}{\not\vdash_{\text{SAT}} \Gamma \vdash \bar{x} \triangleright \Delta}$$

Test a single SAT root for inhabitants

$$\frac{\boxed{\not\vdash_{\text{SAT}} \Gamma \vdash x \triangleright \Delta} \quad \not\vdash_{\text{SAT}} \Gamma \vdash \oplus \Delta x \approx \perp \quad \{\bar{K}\} \text{ COMPLETE set} \quad \overline{\forall \bar{y} : \bar{\tau}. \not\vdash_{\text{SAT}} \Gamma, \bar{y} : \bar{\tau} \vdash \oplus \Delta x \approx K \bar{y}}}{\not\vdash_{\text{SAT}} \Gamma \vdash x \triangleright \Delta}$$

Add a single equality to Δ

$$\boxed{\not\vdash_{\text{SAT}} \Gamma \vdash \oplus \Delta \delta}$$

Term stuff: Bottom, negative info, positive info + generativity, positive info + univalence

$$\frac{x \not\approx sth \in \Delta}{\not\vdash_{\text{SAT}} \Gamma \vdash \oplus \Delta x \approx \perp} \quad \frac{x \approx K \bar{y} \in \Delta}{\not\vdash_{\text{SAT}} \Gamma \vdash \oplus \Delta x \approx \perp}$$

$$\frac{x \not\approx K \in \Delta}{\not\vdash_{\text{SAT}} \Gamma \vdash \oplus \Delta x \approx K \bar{y}} \quad \frac{x \approx K_i \bar{y} \in \Delta \quad i \neq j \quad K_i \text{ and } K_j \text{ generative}}{\not\vdash_{\text{SAT}} \Gamma \vdash \oplus \Delta x \approx K_j \bar{z}}$$

$$\frac{x \approx K \bar{\tau} \bar{y} \in \Delta \quad \not\vdash_{\text{SAT}} \Gamma \vdash \oplus \Delta \tau_i \sim \sigma_i}{\not\vdash_{\text{SAT}} \Gamma \vdash \oplus \Delta x \approx K \bar{\sigma} \bar{z}} \quad \frac{x \approx K \bar{\tau} \bar{y} \in \Delta \quad \not\vdash_{\text{SAT}} \Gamma \vdash \oplus \Delta y_i \approx z_i}{\not\vdash_{\text{SAT}} \Gamma \vdash \oplus \Delta x \approx K \bar{\sigma} \bar{z}}$$

Type stuff: Hand over to unspecified type oracle

$$\frac{\tau_1 \text{ and } \tau_2 \text{ incompatible to Givens in } \Delta \text{ according to type oracle}}{\not\vdash_{\text{SAT}} \Gamma \vdash \oplus \Delta \tau_1 \sim \tau_2}$$

Mixed: Instantiate K and see if that leads to a contradiction TODO: Proper instantiation

$$\frac{\overline{\not\vdash_{\text{SAT}} \Gamma \vdash y \triangleright \Delta \cup y \not\approx \perp}}{\not\vdash_{\text{SAT}} \Gamma \vdash \oplus \Delta x \approx K \bar{y}}$$