GADTs Meet Their Match:

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

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Pattern Syntax

$$
\begin{array}{rlll}
K \in & \text{Con} & & \\
x, y, a, b \in & \text{Var} & & \\
\tau, \sigma \in & \text{Type} & & \\
e \in & \text{Expr} & ::= & x : \tau \\
 & & \mid & K\ \overline{a}\ \overline{\gamma}\ \overline{e : \tau} \\
 & & \mid & \ldots \\
\gamma \in & \text{TyCt} & ::= & \tau_1 \sim \tau_2 \mid \ldots \\
g \in & \text{Grd} & ::= & \text{let } x : \tau = e; \\
 & & \mid & K\ \overline{a}\ \overline{\gamma}\ \overline{y : \tau} \leftarrow x; \\
 & & \mid & !x;
\end{array}
$$

Oracle Syntax

$$
\begin{array}{rlll}
\Gamma & ::= & \varnothing \mid \Gamma, x : \tau \mid \Gamma, a & \text{Context} \\
\Delta & ::= & \times \mid \checkmark \mid \Delta, \delta \mid \Delta_1 \vee \Delta_2 & \text{Delta} \\
\delta & ::= & \gamma \mid x_1 \approx x_2 \mid K\ \overline{x : \tau} \leftarrow y \mid x \not\approx K \mid x \approx \bot \mid x \not\approx \bot \mid x \approx e & \text{Constraints}
\end{array}
$$

TODO LIST

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Clause tree

$$
\begin{array}{rcl}
\mathcal{T}[r] & ::= & \texttt{Rhs} \\
& | & \texttt{Many}\ \overline{r} \\
\\
t_G \in \text{Gdt} & ::= & \mathcal{T}[t_G] \\
& | & \texttt{Guard}\ g\ t_G \\
\\
t_C \in \text{Ctt} & ::= & \mathcal{T}[t_C] \\
& | & \texttt{DivergeIf}\ \delta\ t_C \\
& | & \texttt{FallThroughIf}\ \delta\ t_C \\
& | & \texttt{Refine}\ \delta\ t_C \\
\\
t_A \in \text{Ant} & ::= & \mathcal{T}[t_A] \\
& | & \texttt{MayDiverge}\ t_A \\
& | & \texttt{Inaccessible}\ t_A
\end{array}
$$

Compiling constraint trees

$$\boxed{\texttt{cct Gdt} = \text{Ctt}}$$

$$
\begin{array}{lcl}
\texttt{cct Rhs} & = & \texttt{Rhs} \\
\texttt{cct Many}\ \overline{t_G} & = & \texttt{Many}\ \overline{\texttt{cct}\ t_G} \\
\texttt{cct Guard}\ (\text{let}\ x = e;)\ t_G & = & \texttt{cctg}\ g\ (\texttt{cct}\ t_G) \\
\texttt{cctg}\ (\text{let}\ x = e;) & = & \texttt{Refine}\ (x \approx e) \\
\texttt{cctg}\ (!x;) & = & \texttt{DivergeIf}\ (x \approx \bot)\ \circ \texttt{Refine}\ (x \not\approx \bot) \\
\texttt{cctg Guard}\ (!x;) & = & \texttt{DivergeIf}\ (x \approx \bot)\ \circ \texttt{Refine}\ (x \not\approx \bot) \\
\texttt{cct Guard}\ (K\ \overline{a}\ \overline{\gamma}\ \overline{y : \tau} \leftarrow x;)\ t_G & = & \texttt{DivergeIf}\ (x \approx \bot)\ (\texttt{DivergeIf}\ (x \approx \bot)\ (\texttt{Refine}\ (x \approx K\ \overline{x : \tau} \leftarrow y)
\end{array}
$$

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Test if Oracle state Delta is unsatisfiable

$$\frac{\boxed{\nvdash_{\text{SAT}} \Gamma \vdash \Delta} \qquad \nvdash_{\text{SAT}} \Gamma \vdash fvs\Gamma \triangleright \Delta}{\nvdash_{\text{SAT}} \Gamma \vdash \Delta}$$

Test a list of SAT roots for inhabitants

$$\frac{\boxed{\nvdash_{\text{SAT}} \Gamma \vdash \overline{x} \triangleright \Delta} \qquad \nvdash_{\text{SAT}} \Gamma \vdash x_i \triangleright \Delta}{\nvdash_{\text{SAT}} \Gamma \vdash \overline{x} \triangleright \Delta}$$

Test a single SAT root for inhabitants

$$\frac{\boxed{\nvdash_{\text{SAT}} \Gamma \vdash x \triangleright \Delta} \qquad \nvdash_{\text{SAT}} \Gamma \vdash \oplus \Delta x \approx \bot \quad \{\overline{K}\} \text{ COMPLETE set} \quad \overline{\forall \overline{y:\tau}.\, \nvdash_{\text{SAT}} \Gamma, \overline{y:\tau} \vdash \oplus \Delta x \approx K\ \overline{y}}}{\nvdash_{\text{SAT}} \Gamma \vdash x \triangleright \Delta}$$

Add a single equality to Δ

$$\boxed{\nvdash_{\text{SAT}} \Gamma \vdash \oplus \Delta\delta}$$

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

$$\frac{x \not\approx sth \in \Delta}{\nvdash_{\text{SAT}} \Gamma \vdash \oplus \Delta x \approx \bot} \qquad \frac{x \approx K\ \overline{y} \in \Delta}{\nvdash_{\text{SAT}} \Gamma \vdash \oplus \Delta x \approx \bot}$$

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

$$\frac{x \approx K\ \overline{\tau}\ \overline{y} \in \Delta \quad \nvdash_{\text{SAT}} \Gamma \vdash \oplus \Delta\tau_i \sim \sigma_i}{\nvdash_{\text{SAT}} \Gamma \vdash \oplus \Delta x \approx K\ \overline{\sigma}\ \overline{z}} \qquad \frac{x \approx K\ \overline{\tau}\ \overline{y} \in \Delta \quad \nvdash_{\text{SAT}} \Gamma \vdash \oplus \Delta y_i \approx z_i}{\nvdash_{\text{SAT}} \Gamma \vdash \oplus \Delta x \approx K\ \overline{\sigma}\ \overline{z}}$$

Type stuff: Hand over to unspecified type oracle

$$\frac{\tau_1 \text{ and } \tau_2 \text{ incompatible to Givens in } \Delta \text{ according to type oracle}}{\nvdash_{\text{SAT}} \Gamma \vdash \oplus \Delta\tau_1 \sim \tau_2}$$

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

$$\frac{\overline{\nvdash_{\text{SAT}} \Gamma \vdash y \triangleright \Delta \cup y \not\approx \bot}}{\nvdash_{\text{SAT}} \Gamma \vdash \oplus \Delta x \approx K\ \overline{y}}$$

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