# Introduction to Beamer

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# This is the title

Beamer is a LaTeX class for preparing presentations.

1. Slides are called frames in Beamer.
2. This is the usual ordered list in LaTeX.
3. Following slides will content random content which will show you various ways of using it. You need to replicate it.
4. Of course! we will give you boilerplate code!

# Type Rules

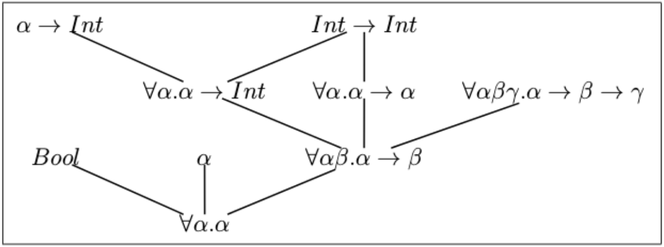



Figure: This is the caption.

# Type Rules

- A *substitution* is a list of pairs denoted as $S = \{\alpha_1/\tau_1 \ldots \alpha_n/\tau_n\}$.
- A substitution $S$ applied on a type expression $\sigma$, denoted by $S(\sigma)$ involves simultaneous substitution of the variables $\alpha_1 \ldots \alpha_n$, if they occur free in $\sigma$, by the corresponding type expressions $\tau_1 \ldots \tau_n$.

**Definition**

Let $\sigma = \forall \alpha_1 \ldots \alpha_m . \tau$ and $\sigma' = \forall \beta_1 \ldots \beta_n . \tau'$. Then $\sigma'$ is a *generic instance* of $\sigma$, iff there is a substitution $S$ acting only on $\{\alpha_1 \ldots \alpha_m\}$ such that $\tau' = S(\tau)$ and no $\beta_i$ is free in $\sigma$.

- Clearly, the restriction that no $\beta_i$ is free in $\sigma$ is needed, else we would have absurdities like $\alpha \rightarrow Int \leq \forall \alpha . \alpha \rightarrow Int$.

# Recapitulation – Type rules for $\lambda_2$

$$\Gamma \cup \{x :: \sigma\} \vdash x :: \sigma \qquad \text{(Var)}$$

$$\Gamma \cup \{c :: \sigma\} \vdash c :: \sigma \qquad \text{(Con)}$$

$$\frac{\Gamma \vdash M :: \sigma \qquad \sigma' \geq \sigma}{\Gamma \vdash M :: \sigma'} \qquad \text{(Inst)}$$

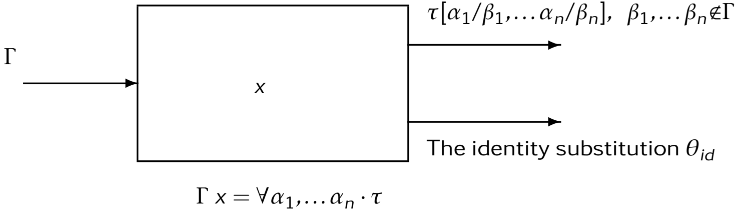
$$\frac{\Gamma \vdash M :: \sigma \qquad \alpha \notin FV(\Gamma)}{\Gamma \vdash M :: \forall \alpha.\sigma} \qquad \text{(Gen)}$$

$$\frac{\Gamma \vdash M :: \tau_1 \rightarrow \tau_2 \qquad \Gamma \vdash N :: \tau_1}{\Gamma \vdash M\ N :: \tau_2} \qquad \text{(M-App)}$$

$$\frac{\Gamma, x :: \tau_1 \vdash M :: \tau_2}{\Gamma \vdash \lambda x.M :: \tau_1 \rightarrow \tau_2} \qquad \text{(M-Abs)}$$

# Hindley-Milner - Type checking variables

1: $t$ **is a variable** $x$




- $\beta_1,\ldots,\beta_n$ are fresh variables.
- Reason for monomorphising the type of $x$: We try to find the type of a variable only in the context of an application, and our application is monomorphic.

# Hindley-Milner - Type checking applications

1. Typecheck $e_1$ with the initial environment $\Gamma$. Result is $\tau_1$ and $\theta_1$.
2. Typecheck $e_2$ with the environment $\theta_1\ \Gamma$. Result is $\tau_2$ and $\theta_2$.
3. Unify $\theta_2\ \tau_1$ and $\tau_2 \rightarrow \alpha$. Assume that unifier is $\theta$. And the unified term $(\theta\ \alpha)$ is $\tau_3$.
4. Type of the application is $\tau_3$ and the final substitution is $\theta \circ \theta_2 \circ \theta_1$.