Равенство в Теории Типов

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Intentional Type Theory

Per Martin-Löf "An Intuitionstic Theory of Types: Predicative Part", 1975

Definitional equality $=_{\mathrm{def}}$

Definition, Equivalence, αβ, $\dfrac{a =_{\mathrm{def}} b}{x[a] =_{\mathrm{def}} x[b]}$,

$$\frac{a : A \qquad A =_{\mathrm{def}} B}{a : B}\ .$$

Propositional equality (a.k.a. Identity) $I(A, a, b)$

$$r(a) : I(A, a, a)$$

$$\dfrac{\dfrac{x : A \qquad y : A \qquad z : I(A, x, y)}{C[x, y, z]} \qquad c[x] : C[x, x, r(x)]}{f(x, x, r(x)) =_{\mathrm{def}} c[x]}$$

TODO: Also mention J as a modern alternative.

Extentional Type Theory

Per Martin-Löf "Intuitionstic Type Theory", 1980

Definitional equality

Definition, Equivalence, Substituiting equals for equals, α. Checking that in $\dfrac{A \qquad B}{A \& B}$ A, B on top are the same (i.e. definitionally equal) to the ones on the bottom.

Judgemental equality $A = B$, $a = b : A$

Defined for every type, $\beta\eta$,

$$\xi \, \frac{\begin{array}{c}[x : A] \\ f(x) = g(x) : B(x)\end{array}}{\lambda x.\ f(x) = \lambda x.\ g(x) : \Pi(x : A)B(x)} \,,$$

$$\frac{a \in A \qquad A = B}{a \in B} \,, \quad \frac{a = b \in A \qquad A = B}{a = b \in B} \,.$$

Propositional equality

$$\text{ER} \, \frac{c : I(A, a, b)}{a = b : A} \,, \quad \text{UIP} \, \frac{c : I(A, a, b)}{c = r : I(A, a, b)} \,.$$

Observational Type Theory

Definitional equality: αβη.
Propositional equality is heterogeneous equality:
$(x : A) = (y : B)$, $\quad$ $\mathit{refl} : (x : A) \to (x : A) = (x : A)$. Coercion:
$$\frac{p : S_0 = S_1 \qquad s_0 : S_0}{s_0[p\rangle : S_1}$$
Coherence:
$$\frac{p : S_0 = S_1 \qquad s_0 : S_0}{s_0[|p|\rangle : (s_0 : S_0) = (s_0[p\rangle : S_1)}$$
Coercion, coherence rules are defined for each and every type.
Result: propositional equality is truly extensional.

Unified Type Theory

ITT + impredicative Prop. Equality is Leibniz:
$\forall P : A \to Prop.\ P(a) \implies P(b)$.

Computational Type Theory

Based on ETT. Define the meaning of $x = y : A$ for the types you want. $x : A$ is then a shortcut for $x = x : A$. And propositional equality is truly identified with judgemental equality.
Set types: $\{x : A | p(x)\}$ Quotient types: $(x, y) : A//E$. Change an equivalence relation to E.

Homotopy Type Theory

Definitionally like ITT but with η.
Proof relevance for equality. Think βreduction chain. $a = b : A$ when there is a path from a to b. As such no UIP (and K). OTOH have function extensionality.

ZOMBIE

Forget automatic β. Get equality relations from the context and use them.