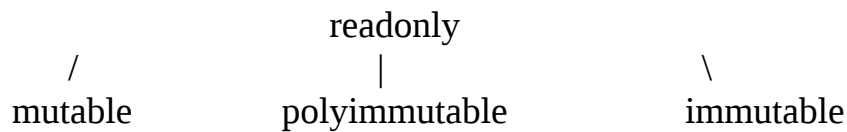cd ::= class C { fd; kd md}   class
fd ::= t f   field
kd ::= q C (t f) { this.f = f}; // Doesn't support subclassing yet   constructor
md ::= t m (t this, tx) {t y s; return y}   instance method
s ::= s;s | x = new t() | x = y | x = y.f | x.f = y | x = y.m(z)   statement
t ::= q C   qualified type
q ::= readonly | polyimmutable | mutable | immutable   qualifier

Type Hierarchy

$$
\begin{array}{ccccc}
 & & \text{readonly} & & \\
 / & & | & & \backslash \\
\text{mutable} & & \text{polyimmutable} & & \text{immutable}
\end{array}
$$

Helper Functions

$$
\frac{q\ C\ f}{\text{typeof}(f) = q}
$$

$$
\frac{m \text{ is annotated with @initialize}}{\text{initializable}(m)}
$$

$$
\frac{x = \text{``this''} \text{ in constructor} \vee ( x = \text{``this''} \text{ in } m \wedge \text{initializable}(m))}{\text{initializable}(x)}
$$

Viewpoint Adaptation Rules

_ ▷ mutable = mutable
_ ▷ readonly = readonly
_ ▷ immutable = immutable
q ▷ polyimmutable = q

Special Rules

- Forbid mutable and readonly on fields
- Forbid readonly on constructor return type
- In constructor, $q_{this} = q_{ret}$

Typing Rules

$$\frac{\Gamma(x) = q_x \quad \Gamma(y) = q_y \quad q_y <: q_x}{\Gamma \vdash x = y} \quad (\text{ T-VAR })$$

$$\frac{\Gamma(x) = q_x \quad \Gamma(y) = q_y \quad \text{typeof}(f) = q_f \quad q_y \rhd q_f <: q_x}{\Gamma \vdash x = y.f} \quad (\text{ T-READ })$$

$$\frac{\Gamma(x) = q_x \quad \Gamma(y) = q_y \quad \text{typeof}(f) = q_f \quad q_y <: q_x \rhd q_f}{q_x = \text{mutable} \lor (\text{ initializable}(x) \land q_x = \{\text{immutable, polyimmutable}\})}{\Gamma \vdash x.f = y} \quad (\text{ T-WRITE })$$

$$\frac{\begin{array}{c}\Gamma(x) = q_x \quad \Gamma(y) = q_y \quad \Gamma(z) = q_z \quad \text{typeof}(m) = q_{this}, q_p \to q_{ret} \\ q_y <: q_x \rhd q_{this} \qquad q_z <: q_x \rhd q_p \qquad q_x \rhd q_{ret} <: q_x \\ !\text{ inside constructor} \land !(\text{inside } m' \land \text{initializable}(m')) \to !\text{ initializable}(m)\end{array}}{\Gamma \vdash x = y.m(z)} \quad (\text{ T-INVK })$$

$$\frac{\begin{array}{c}\Gamma(x) = q_x \quad \Gamma(y) = q_y \quad \text{typeof}(C) = q_p \to q_{ret} \\ q_y <: q \rhd q_P \qquad q <: q \rhd q_{ret} \\ q_x = \text{mutable} \lor \text{immutable}\end{array}}{\Gamma \vdash x = \text{new } q\ C(y)} \quad (\text{ T-NEW })$$