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Discuss the pros and cons of call-by-value and call-by-name semantics.

[3]

Consider the syntax of the following pure functional language

$$\begin{aligned} e &::= n \mid \mathbf{fn} \ x:T \Rightarrow e \mid e \ e \mid x \mid \Omega \\ T &::= \mathbf{int} \mid T \rightarrow T \end{aligned}$$

where the static and dynamic semantics of Ω are given by rules

$$\text{(omega)} \quad \frac{}{\Gamma \vdash \Omega:\mathbf{int}} \quad \text{(omega)} \quad \Omega \longrightarrow \Omega$$

Give typing rules and CBN dynamic semantic rules for the other constructs.

[6]

Give an expression that would behave differently in the CBV and CBN semantics, and give its final state in each (if any).

[2]

For this language, the desired type preservation result would be of the form “If $\Gamma \vdash e:T$ and $e \longrightarrow e'$ then $\Gamma \vdash e':T$ ”. In proving that, a substitution lemma would be required. Give a statement and proof of that substitution lemma.

[9]