Assignment on Declarative Semantics

I.

Exercise: Extended coherence order

Let G be a coherent execution wrt some modification order mo for G.

Let $\text{eco} \triangleq (\text{rf} \cup \text{mo} \cup \text{rb})^+$.

1. Does eco totally order all accesses to a given location x?

2. Provide a simplification of eco that avoids the use of transitive closure.

II.

Exercise: RA vs. TSO

Do RA and TSO have the same behaviors?

1. Construct a program with two threads that has different outcomes under TSO and RA.

2. Construct a program without write-write races that distinguishes the two models.

III. In the class, we showed you a theorem on an alternative definition of RA consistency (see below).

> **Theorem**
>
> *Let* mo *be a modification order for an execution graph G. G is* RA*-consistent wrt* mo *iff the following hold:*
>
> ▸ $(\text{po} \cup \text{rf})^+$ *is irreflexive.*   *(no-future-read)*
>
> ▸ $\text{mo} ; (\text{po} \cup \text{rf})^+$ *is irreflexive.*   *(coherence-ww)*
>
> ▸ $\text{rf}^{-1} ; \text{mo} ; (\text{po} \cup \text{rf})^+$ *is irreflexive.*   *(coherence-wr)*
>
> ▸ $\text{rf}^{-1} ; \text{mo} ; \text{mo}$ *is irreflexive.*   *(rmw-atomicity)*

In each (separate) problem below, we will replace one condition of the theorem with some weaker condition (while we keep other parts of the theorem unchanged), and you job is to tell whether the theorem still holds. If it still holds, just say yes. Otherwise, you need to explain why, by giving an example program and an execution graph of the program (with the modification order), such that the execution graph satisfies the new conditions but it is not RA-consistent.

1. Replace the (no-future-read) condition ($(\text{po} \cup \text{rf})^+$ is irreflexive) with the following condition:

$$\text{rf} ; \text{po} \text{ is irreflexive, and } \text{rf} \text{ is irreflexive.}$$

2. Replace the (coherence-ww) condition ($\text{mo} ; (\text{po} \cup \text{rf})^+$ is irreflexive) with the following condition:

$$\text{mo} ; \text{po} \text{ is irreflexive, } \text{mo} ; \text{rf} ; \text{po} \text{ is irreflexive, and } \text{mo} ; \text{rf} \text{ is irreflexive.}$$

3. Replace the (coherence-wr) condition ($\text{rf}^{-1} ; \text{mo} ; (\text{po} \cup \text{rf})^+$ is irreflexive) with the following condition:

$$\text{rf}^{-1} ; \text{mo} ; \text{po} \text{ is irreflexive, } \text{rf}^{-1} ; \text{mo} ; \text{rf} ; \text{po} \text{ is irreflexive,}$$
$$\text{and } \text{rf}^{-1} ; \text{mo} ; \text{po} ; \text{rf} ; \text{po} \text{ is irreflexive.}$$