Memory Consistency Models

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  - One common approach is to apply synchronization.
  - But the degree of synchronization must be minimal.
  - Basically synchronization controls the order of read and write to shared memory locations.
  - Without sychronization the order of read and writes may be altered either by compiler (optmizations) or by hardware for better performance.

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- The objective.
  - Less compromise on performance - With less degree of synchronization shall we get acceptable output ????
  - Arguing about the correctness of the program.

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Sequential Consistency (SC)

- Uniprocessor - A "read" returns the last "write" in program order.
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- **Sequential consistency** - An intuitive extension of uniprocessor model.
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- An Example [**?**]

Initially $X = Y = 0$

Red Thread	Blue Thread
X = 1;	Y = 1;
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- Some possible interleavings.

Execution 1	Execution 2	Execution 3
X = 1;	Y = 1;	X = 1;
r1 = Y;	r2 = X;	Y = 1;
Y = 1;	X = 1;	r1 = Y;
r2 = X;	r1 = Y;	r2 = X;
//r1 == 0;	//r1 == 1;	//r1 == 1;
//r2 == 1;	//r2 == 0;	//r2 == 1;

Relaxed Consistency (RC)

- SC is hard to realize.
- Too much restriction for hardware and compiler optmizations
- Even SC may not always be produce correct output.
- So we can live with **Relaxed Consistency Models**.
- Potential relaxations
  - Program order: (Refers to different memory locations)
    - Relax $W \rightarrow R$ program order.
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    - Relax $R \rightarrow R$ and $R \rightarrow W$ program order.
  - Write atomicite: (Refers to same memory location)
    - Read others' write early.
  - Write atomicity and program order.
    - Read own write early

Total Store Order (TSO)

Model	$W \rightarrow R$ order	$W \rightarrow W$ order	$R \rightarrow RW$ order	R Others' W Early	R Own W Early
TSO	$\surd$				$\surd$

Relaxed Consistency (RC)

- Same program may exhibit more executions on a relaxed model than SC [**?**].
- Let T_{Π}^{Y} be the set of executions on memory model Y. Then $T_{\Pi}^{Y} \subset T_{\Pi}^{SC}$ [**?**].
- To verify relaxed executions T_{Π}^{Y}, verify following two problems.
  - Use standard verification methodology for concurrent programs to show that the executions in T_{Π}^{SC} are correct.
  - Use specialized methodology for *memory model safety* verification showing that $T_{\Pi}^{Y} = T_{\Pi}^{SC}$.
  - The program is $Y - safe$ if $T_{\Pi}^{Y} = T_{\Pi}^{SC}$.

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