第十五讲：死锁和并发错误检测

第 5 节：并发错误检测

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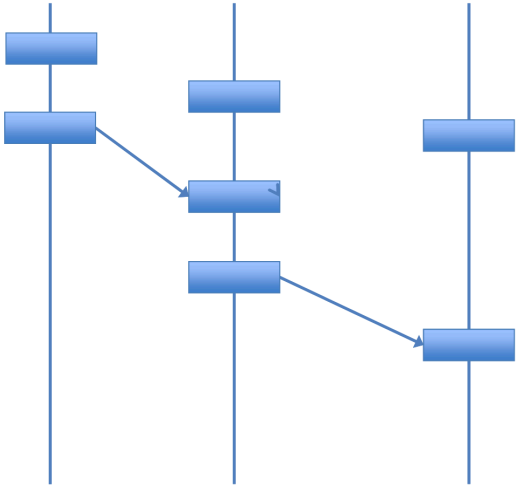
提纲

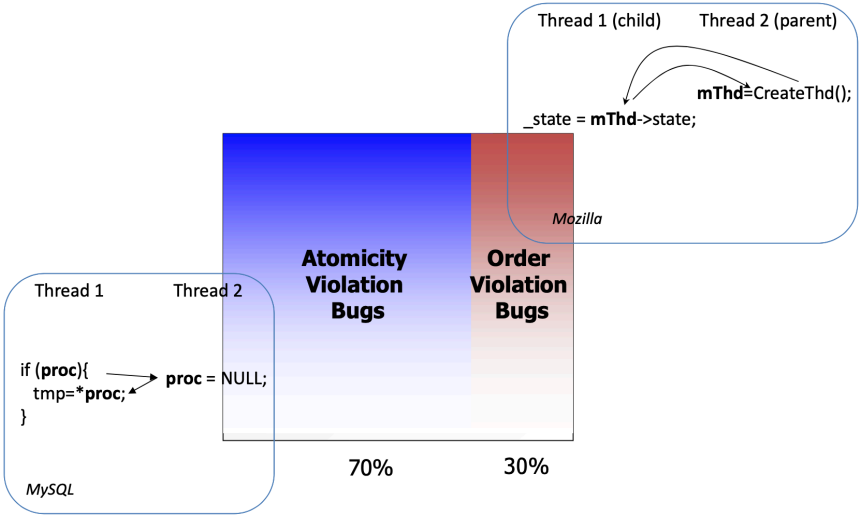
Ref: Shan Lu, Detecting and Fixing Concurrency Bugs, University of Chicago

Concurrency bug

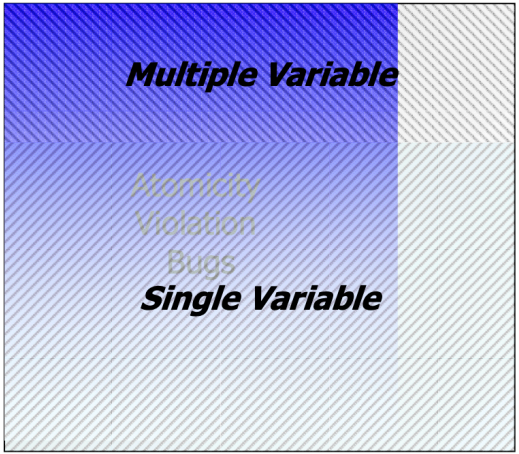
What ordering is guaranteed?



Concurrency bug: Voilation



Concurrency bug: Variable



Atomicity Violations

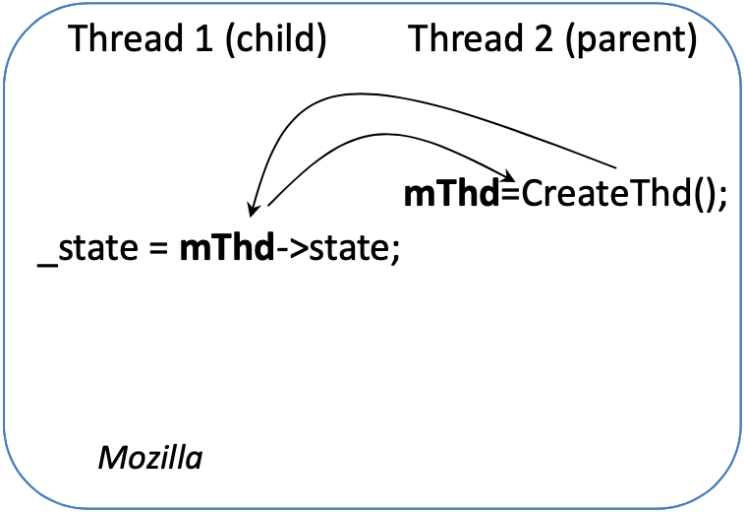
Thread 1	Thread 2

if (**proc**){
  tmp=***proc**;
}
	proc = NULL;

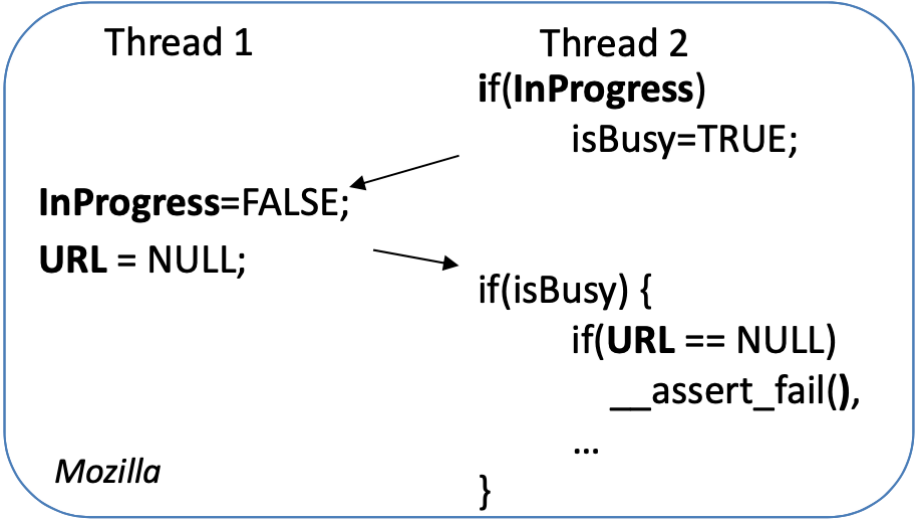
MySQL

Thread 1	Thread 2
while (!flag) {};	flag=TRUE;

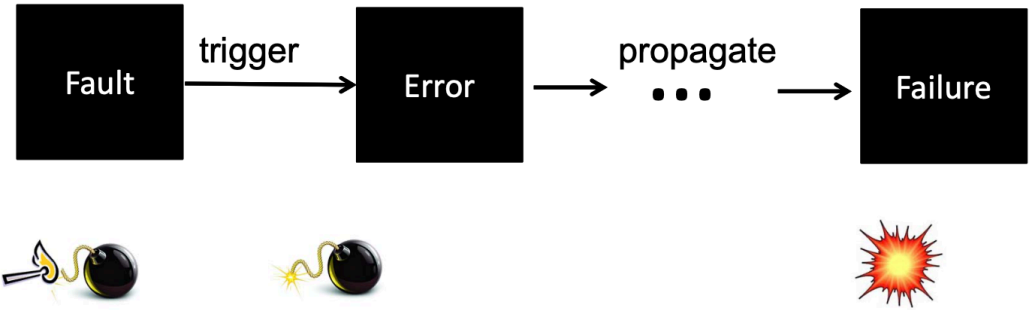
Order Violations



Multi-var Order Violations



The lifecycle of bugs



logical clock algorithm

Use logic time-stamps to find concurrent accesses

Thread 1	Thread 2	
	lock (L);	<0,1>
	ptr=NULL;	<0,2>
	unlock(L);	<0,3>

<1,0>**ptr** = malloc(10);
<2,3>lock (L);
<3,3>**ptr**[0]='a';
<4,3>unlock(L);

Lock-set algorithm

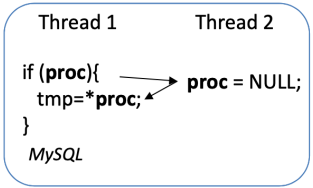
A common lock should protect all conflicting accesses to a shared variable

	Thread 1	Thread 2	
		lock (L);	
		ptr=NULL;	<L>
		unlock(L);	

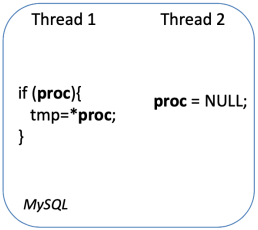
</>	**ptr** = malloc(10);	
	lock (L);	
<L>	**ptr**[0]='a';	
	unlock(L);	

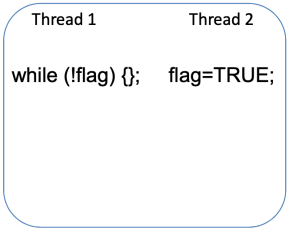
How to detect atomicity-violations?

Know which code region should maintain atomicity

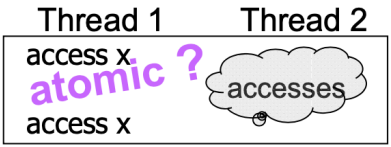


Judge whether a code region's atomicity is violated

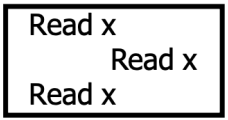


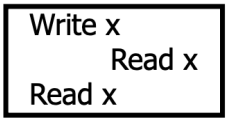


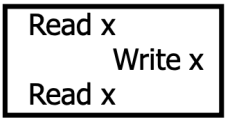
Atomicity violation = unserializable interleaving

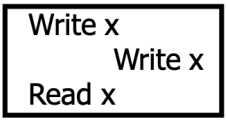


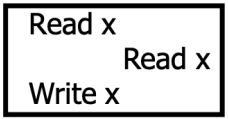
Totally 8 cases of interleaving

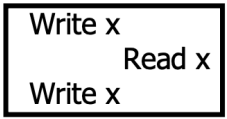


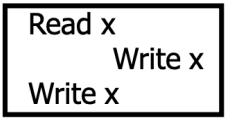


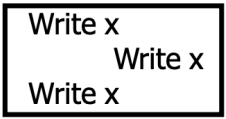




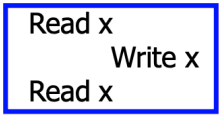


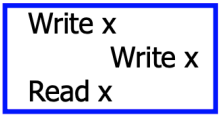


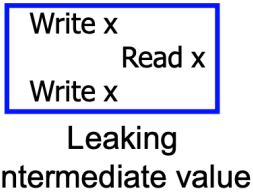


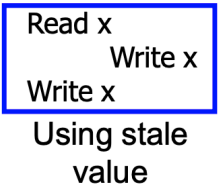


4 out of 8 cases are interleaving violations









Both hardware and software solutions exist

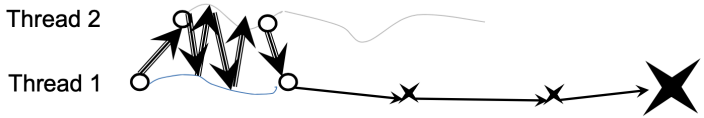
ConSeq & ConMem

If we cannot find a more accurate root-cause pattern, let's look at the effect patterns of concurrency bugs!

- ConMem
  - Detecting Severe Concurrency Bugs through an Effect-Oriented Approach, ASPLOS' 10
- ConSeq
  - Detecting Concurrency Bugs through Sequential Errors, ASPLOS' 11

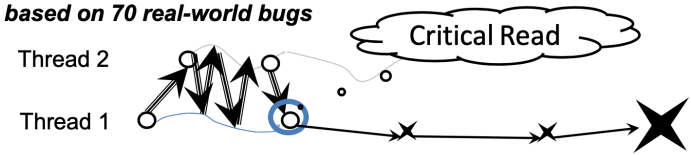
The lifecycle of concurrency bugs: Fault

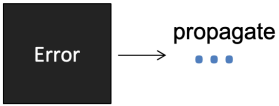
based on 70 real-world bugs



Data races
Atomicity violations
  single variable
  multiple variables
Order violations
…

The lifecycle of concurrency bugs: Error

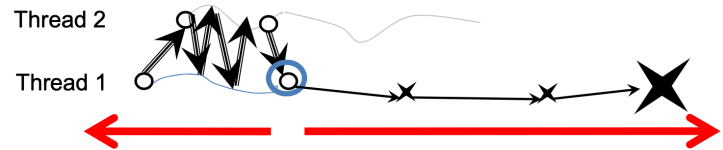




- Memory errors
  - NULL ptr
  - Dangling ptr
  - Uninitialized read
  - Buffer overflow
- Semantic errors

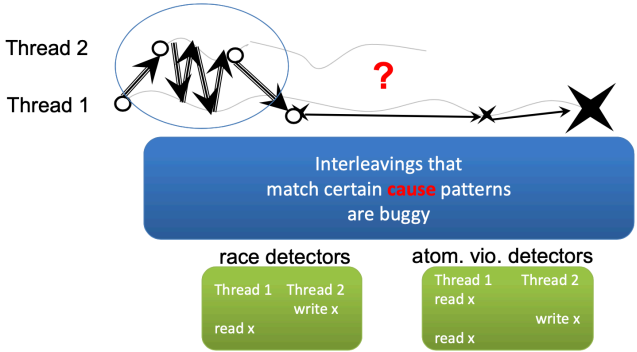
The lifecycle of concurrency bugs: Failure

based on 70 real-world bugs



- Crash @ invalid memory
- Crash @ assertion
- Infinite loops
- Incorrect outputs
- Error messages

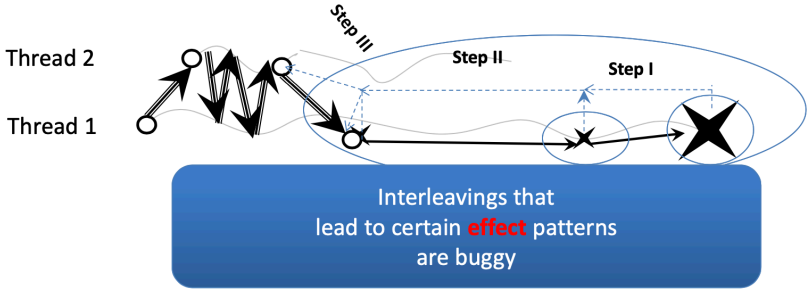
Cause-oriented approach



Limitations

- False positives
- False negatives

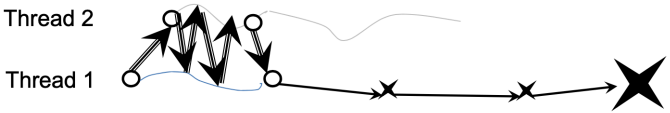
Effect-oriented approach

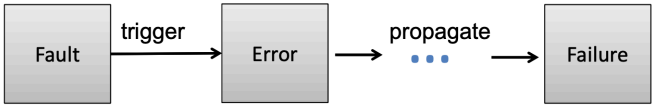


- Step 1: Statically identify potential failure/error site
- Step 2: Statically look for critical reads
- Step 3: Dynamically identify buggy interleaving

ConMem

Detecting Severe Concurrency Bugs through an Effect-Oriented Approach, ASPLOS' 10





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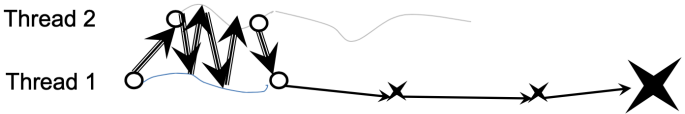
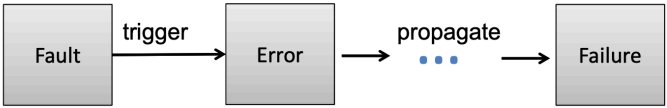
ConSeq: Detecting Concurrency Bugs through Sequential Errors, ASPLOS'11





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