MagicFuzzer: Scalable Deadlock Detection for Large-Scale Applications

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Introduction

- Automatic recognition of potential deadlocks
- Resource-deadlocks (non-communication)
- Dynamic method: Runs program and creates log at each critical event
- Largescale
  - Applicable for Firefox, Thunderbird…

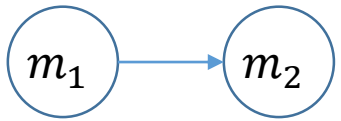
Introduction: Lock dependency

- Dependency relation D: set of lock dependencies
- Lock dependency $< t, m, L >$
  - Thread t
  - Lock m
  - Lockset L
  - t holds all locks of L whilst acquiring m
- Chain of lock dependencies$< t_1, m_1, L_1 >$ … $< t_k, m_k, L_k >$ such that every next thread holds a lock the previous tries to claim
- Deadlock: Cyclic lock dependency chain

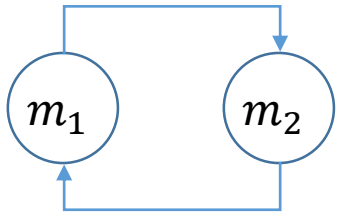
Introduction: Lock dependency graph

- Depicts waits-for dependencies
- Node: lock
- Edge: Waits-for

- $acquire(m_1); acquire(m_2);$



- Deadlock:



Related work

- iGoodLock
- Direct checking on lock order graph
- Multicore SDK
- Constructs a location based lock order graph

Basic algorithm

- Generation of Execution Trace
- Magiclock
- Deadlock Confirmation & MagicScheduler

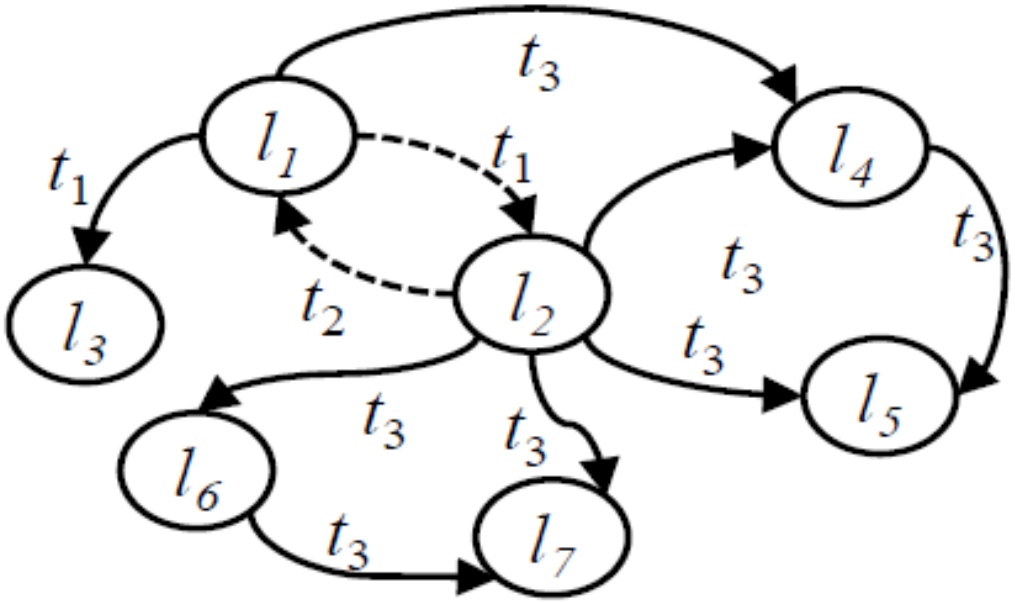
Execution Trace

- Create a log of an execution:

- For every thread creation, create a new lockset L_i
- Whenever acquire occurs
  - append $< t, m, L_i >$
  - $L_i = L_i \cup m$
- Whenever release occurs
  - $L_i = L_i \setminus m$

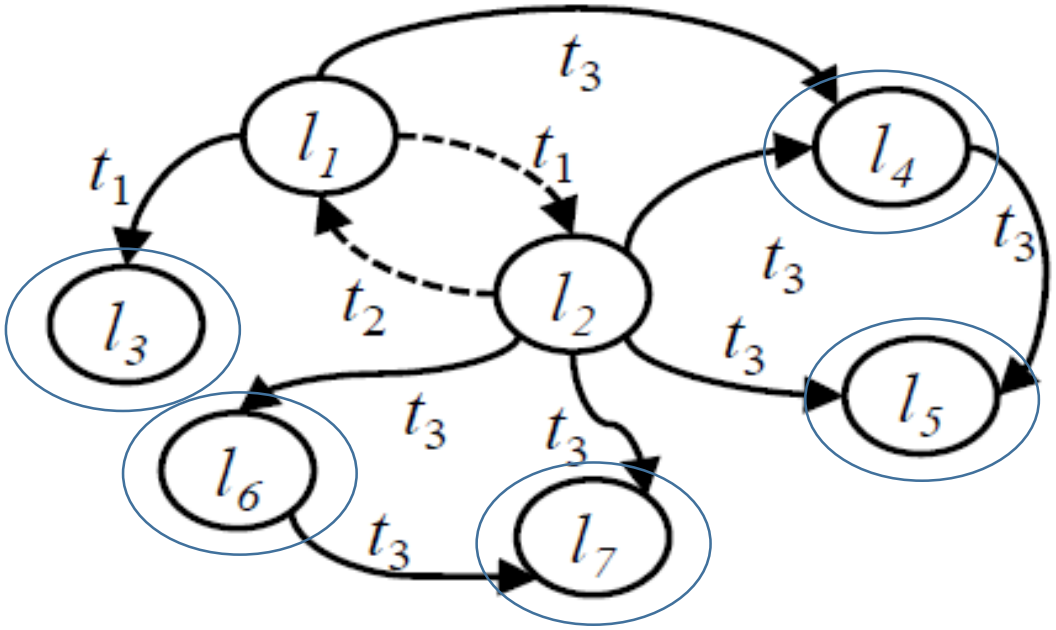
Magiclock

- Uses the log and makes a lock dependency graph from the dependencies
- How can we reduce the size of the graph?



Magiclock

- Only cycles deduct a possible deadlock
- Overfluent nodes:
  - Nodes with no edges
  - Nodes that only have outgoing or ingoing edges
  - Nodes that would be one of the above but are connected to existing ones of the above kind.



Magiclock: Categorization

- Independent-set: In- and outdegree equals 0
- Intermediate-set: In- or outdegree equals 0
- Inner-set: L only contains members of independent / intermediate set
- All others: Cyclic group; subject for possible deadlocks

Deadlock confirmation

- Given detected cycle $m_1 \ldots m_k$
- Gather relevant dependencies $< t, m_i, L >$
- Use DFS to search a cyclic dependency chain such that there is a deadlock

Deadlock confirmation: DFS

```
DFS(threadID, chain)
        For each ID from threadID + 1
                if(isTraversed(threadID)) continue;
                for each dependency d
                        if(chain + d forms a cyclic chain) report;
                        DFS(threadID, chain + d);
                endfor
        endfor
```

MagicScheduler

- Adapts object abstraction from DeadlockFuzzer
- Random scheduler, randomly selecting threads to advance
- At acquire of relevant threads of relevant locks: check for deadlock, pause the thread

- Thrashing: If all threads get put on hold unfavorably, thrashing may happen
- If thrashing happens, a random thread is put out of sleep

Comparison

- iGoodLock
- Direct checking on lock order graph
- Multicore SDK
- Constructs a location based lock order graph

Experiment

- Test of MagicFuzzer compared to other algorithms
- Ubuntu Linux system
- > meaning that the system crashed at the latest measure

Benchmark	Memory(MB)			Time(s)			# of cycles			# of real deadlocks
	iGoodlock	MSDK	Magiclock	iGoodlock	MSDK	Magiclock	iGoodlock	MSDK	Magiclock	
SQLite	1.05MB	1.05MB	1.05MB	0.002s	0.003s	0.002s	1	1	1	1
MySQL	>2.8GB	1.15MB	1.05MB	>2m5s	6m38s	1.73s	>1	1	1	1
Chromium	>2.8GB	>48.2MB	8.01MB	>1h47m	>1h	1m42s	ND	ND	3	UKN
Firefox	>2.8GB	122.41MB	4.14MB	>10m40s	7.43s	3.06s	ND	0	0	0
OpenOffice	245.20MB	>48.4MB	8.01MB	1h46m	>1h	0.67s	0	ND	0	0
Thunderbird	298.83MB	40.09MB	4.15MB	16m13s	4.75s	1.18s	0	0	0	0