Detecting RCU Bugs

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(With a lot of input from Paul McKenney and Frederic Weisbecker)
Not everyone is Paul McKenney*!
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* or Steven Rostedt or Frederic Weisbecker or Mathieu Desnoyers or someone else (in this room or otherwise) who understand RCU well.
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IOW it is easy to write RCU bugs

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Defining RCU

RCU guarantees existence of consistent data within an RCU read critical section
Defining RCU: Correctness
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- RCU protected data is consistent
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- RCU protected data is read only
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- Garbage collection must take place
Defining RCU: Consistency
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A data structure is defined to be consistent if (maybe iff) it meets a set of programmer defined invariants for that structure.
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Defining RCU: Correctness

- RCU protected data is consistent
- RCU protected data is guaranteed to remain in existence
- RCU protected data is read only
- RCU protected data is read only or a well defined update policy
- Garbage collection must take place
RCU Bugs

- Correctness Bugs
  - The ones we care about

- Performance Bugs
  - Blame Paul for these!
Correctness bugs

- Garbage collection must take place after grace period
  - Run too early
  - Access protected data outside CS
  - CS never ends

- RCU protected data is read only
  - Protected data is modified

- RCU protected data is consistent
  - Data is inconsistent
Detecting Pointer Leaks

Pre-existing techniques for race detection

Lockset?

No locks

What if we convert RCU into locks?
RCU <-> Locks

- Easy to convert rwlocks to RCU

- What about converting RCU to rwlocks?

- Need a new transformation
  - Need functional equivalence
RCU <-> rwlocks
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- Multiple versions of given data item
  - Each version is protected by its own rwlock
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- rcu_read_lock()
  - Let the system know a CS has started
- rcu_dereference
  - Grab the private rwlock in read mode
RCU <-> rwlocks

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  ○ Each version is protected by its own rwlock
● rcu_read_lock()
  ○ Let the system know a CS has started
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● rcu_read_unlock()
  ○ Drop all the private rwlocks and end the CS
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- Cleanup
  - Only place where you go write mode
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  - Only place where you go write mode
  - Should NEVER block!
RCU <-> rwlocks
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- Very Complex!
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- Fails the paulmck test
  - Way too many corner cases
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- What else could we do?
RCU <-> rwlocks

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- Fails the paulmck test
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- What else could we do?
  - I really wish I could watch all RCU protected data!
Unlimited Watchpoints
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- My apologies to other architectures
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- x86-64 uses only 48 bits for addressing
  - The upper 16 bits are always set
  - Else, we have a GP
Unlimited Watchpoints

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- What if I was expecting a GP?
RCU and Watchpoints
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- Poison all pointers inside rcu_assign_pointer
RCU and Watchpoints

- Poison all pointers inside rcu_assign_pointer
- Add data during rcu_dereference
RCU and Watchpoints

- Poison all pointers inside `rcu_assign_pointer`
- Add data during `rcu_dereference`
- When we enter a GPF, check!
Current Status

- Basic tracepoints are ready
- Basic algorithm to detect RCU issues designed
- Working on emulating instructions
Questions?