Software Transactional Memory "for real"

Armin Rigo

FSCONS 2012

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Introduction

- This talk is about programming multi- or many-core machines

About myself

- Armin Rigo
- “Language implementation guy”
- PyPy project
  - Python in Python
  - includes a Just-in-Time Compiler “Generator” for Python and any other dynamic language

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Motivation

- A single-core program is getting exponentially slower than a multi-core one
- Using several processes exchanging data
  - works fine in some cases
  - but becomes a large mess in others
- Using several threads
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Common solution

- Organize your program in multiple threads
- Add synchronization when accessing shared, non-read-only data

Synchronization with locks

- Carefully place locks around every access to shared data
- How do you know if you missed a place?
  - hard to catch by writing tests
  - instead you get obscure rare run-time crashes
- Issues when scaling to a large program
  - order of acquisition
  - deadlocks

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Synchronization with TM

- TM = Transactional Memory

```
-----------------    ----------------------
Locks                Transactional Memory
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mylock.acquire();      atomic {
x = list1.pop();         x = list1.pop();
list2.append(x);         list2.append(x);
mylock.release();      }
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Locks versus TM

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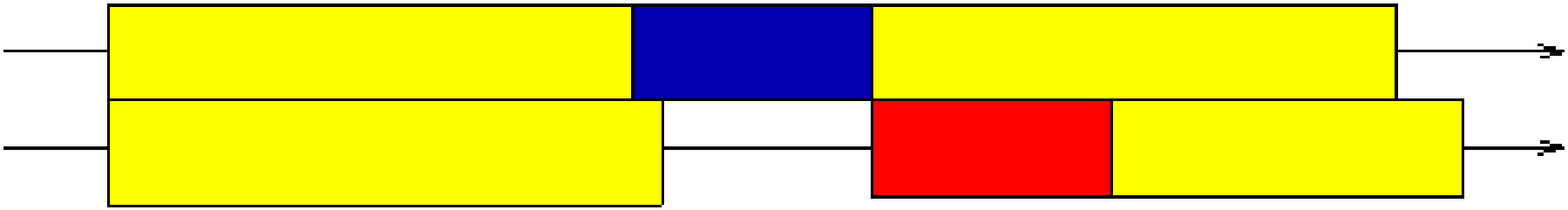

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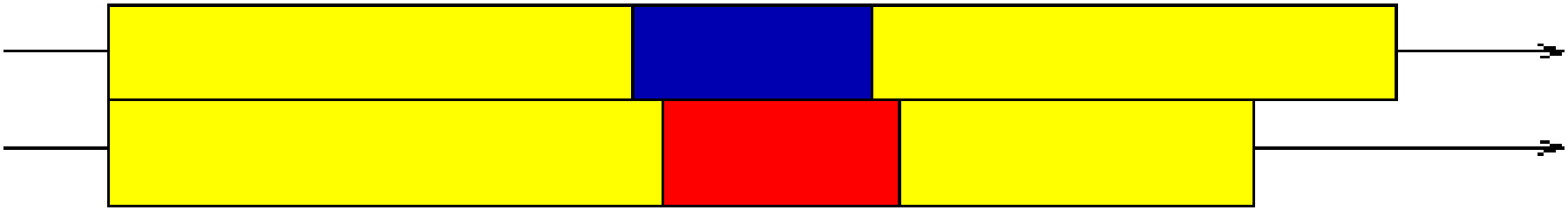

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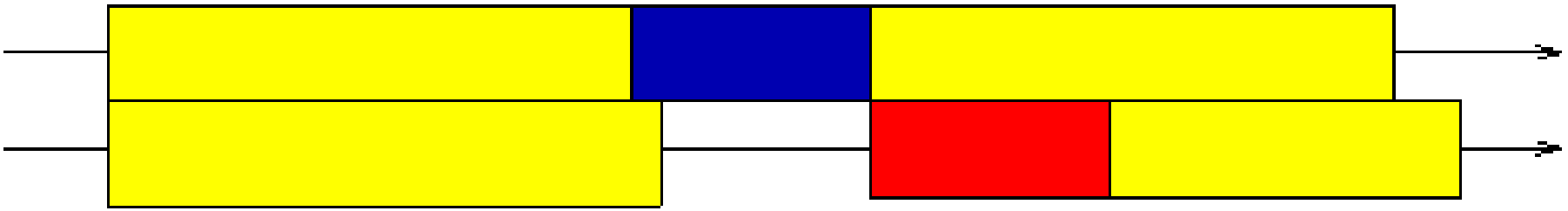
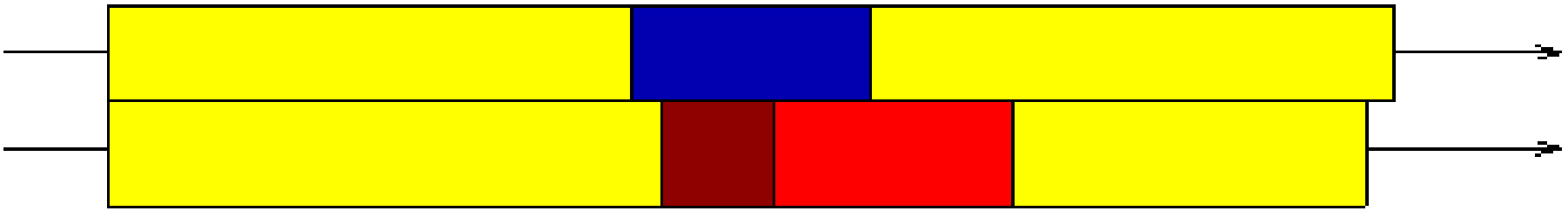


- TM in case of conflict



Synchronization with TM

- “Optimistic” approach:
  - no lock to protect shared data in memory
  - instead, track all memory accesses
  - detect actual conflicts
  - if conflict, restart the whole “transaction”
- Easier to use
  - no need to name locks
  - no deadlocks
  - “composability”

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HTM versus STM

- HTM = Hardware Transactional Memory
  - Intel Haswell CPU, 2013
  - and others
- STM = Software Transactional Memory
  - various approaches
  - large overhead (2x-10x), but getting faster
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Issue with threads

- TM does not solve this problem:
- How do you know if you missed a place to put `atomic` around?
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- What if we put `atomic` everywhere?

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Analogy with Garbage Collection

- Explicit Memory Management:
  - messy, hard to debug rare leaks or corruptions
- Automatic GC solves it
  - common languages either have a GC or not
  - if they have a GC, it controls almost *all* objects
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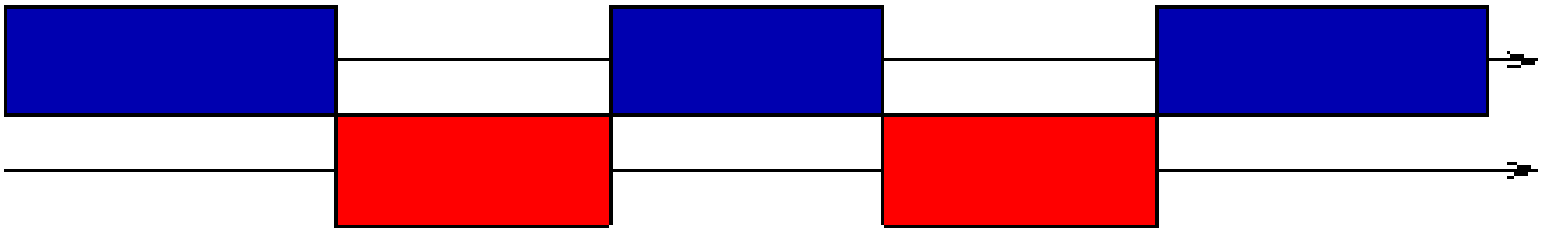
Proposed solution

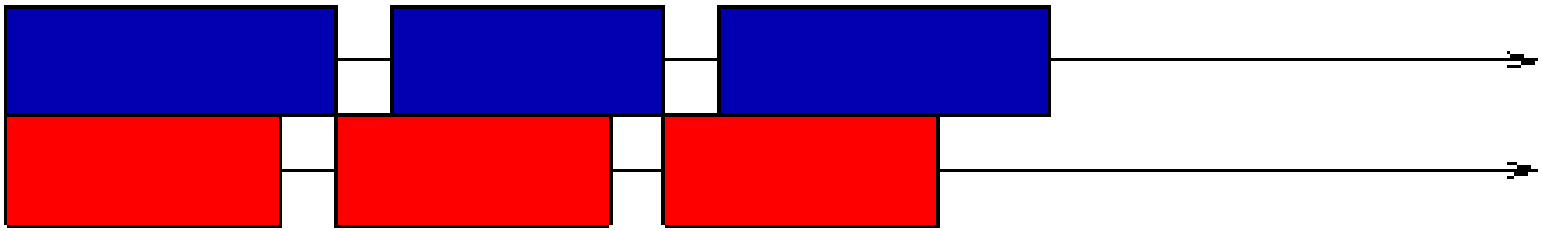
- Put `atomic` everywhere...
- in other words, Run Everything with TM

Proposed solution

- Really needs TM. With locks, you'd get this:



- With TM you can get this:



In a few words

- Longer transactions
- Corresponding to larger parts of the program
- The underlying multi-threaded model becomes implicit

Typical example

- You want to run `f1()` and `f2()` and `f3()`
- Assume they are “mostly independent”
  - i.e. we expect that we can run them in parallel
  - but we cannot prove it, we just hope that in the common case we can
- In case of conflicts, we don’t want random behavior
  - i.e. we don’t want thread-like non-determinism and crashes

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Pooling and atomic statements

- Solution: use a library that creates a pool of threads
- Each thread picks a function from the list and runs it with `atomic`

Results

- The behavior is “as if” we had run `f1()`, `f2()` and `f3()` sequentially
- The programmer chooses if he wants this fixed order, or if any order is fine
- Threads are hidden from the programmer

More generally

- This was an example only
- **TM gives various new ways to hide threads under a nice interface**

Not the Ultimate Solution

- Much easier for the programmer to get reproducible results
- But maybe too many conflicts
- “The right side” of the problem
  - start with a working program, and improve performance
  - as opposed to: with locks, start with a fast program, and debug crashes
  - we will need new debugging tools

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