Transactional Memories: a theoretical introduction

Selim Arsever & Pascal Perez

Shared Memory Problems

M(w,r,v) := w(f).M<w,r,f> + r<v>.M<w,r,v>

A(w,r) := w<v>.WORK.r(v').[v'=v].A

A<w,r> | A<w,r> | M<w,r,v> =

w<v>.WORK.r(v').[v'=v].A |

w<v>.WORK.r(v').[v'=v].A |

w(f).M<w,r,f> + r<v>.M<w,r,v>

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→

w<a>.WORK.r(v').[v'=a].A |

w<v>.WORK.r(v').[v'=v].A |

w(a).M<w,r,f> + r<v>.M<w,r,v>

Shared Memory Problems

M(w,r,v) := w(f).M<w,r,f> + r<v>.M<w,r,v>

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w<a>.WORK.r(v').[v'=a].A |

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Shared Memory Problems

M(w,r,v) := w(f).M<w,r,f> + r<v>.M<w,r,v>

A(w,r) := w<v>.WORK.r(v').[v'=v].A

→

w<a>.WORK.r(v').[v'=a].A |

w<b>.WORK.r(v').[v'=b].A |

w(b).M<w,r,b> + r<a>.M<w,r,a>

Shared Memory Problems

M(w,r,v) := w(f).M<w,r,f> + r<v>.M<w,r,v>

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w(f).M<w,r,f> + r<b>.M<w,r,b>

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A(w,r) := w<v>.WORK.r(v').[v'=v].A

→

w<a>.WORK.r(v').[b=a].A |

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w(f).M<w,r,f> + r<b>.M<w,r,b>

Shared Memory Problems

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w(f).M<w,r,f> + r<b>.M<w,r,b>

Locking is dangerous

- What if a thread fails whilst holding a lock?
- Deadlocks happen!
- Linux pros on http://lwn.net/Articles/86859/

Locking does not scale well

Fine grained locked data structures implementation exist of the shelf but…

Global knowlegde!

Transaction

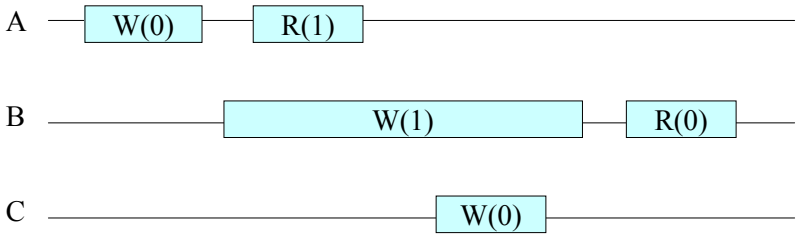
Atomicity
Consistency
Isolation
Durability

Transaction

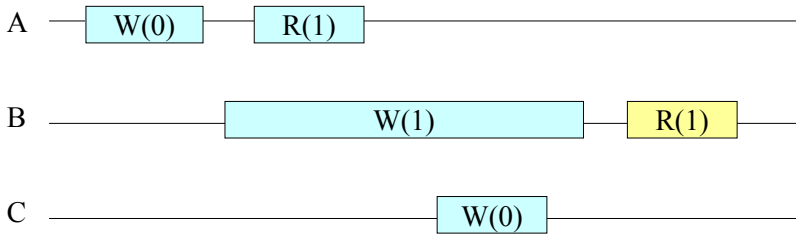
A + B + C should remain constant under the execution of both transactions in any order.

Correct:		Wrong:	
A = A – 10	lock L_1	lock L_1	lock L_2
lock L_1	B = B – 20	A = A – 10	B = B – 20
B = B + 10	unlock L_1	unlock L_1	unlock L_2
unlock L_1	C = C + 20	B = B + 10	C = C + 20

Transactional Memory

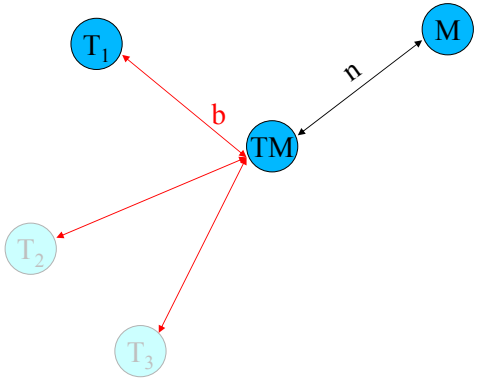


Transactional Memory



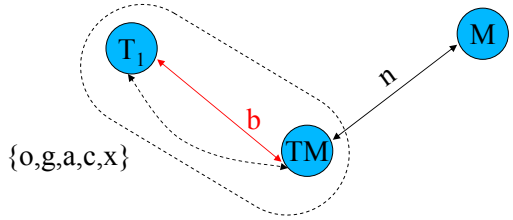
Transactional Memory

Initial Situation:



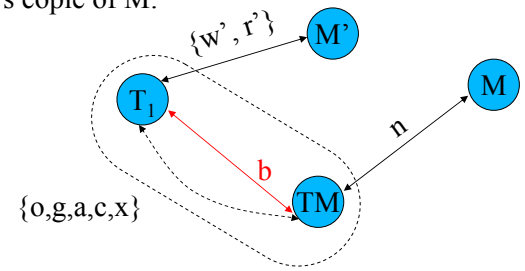
Transactional Memory

T_1 gives his chanels to TM:



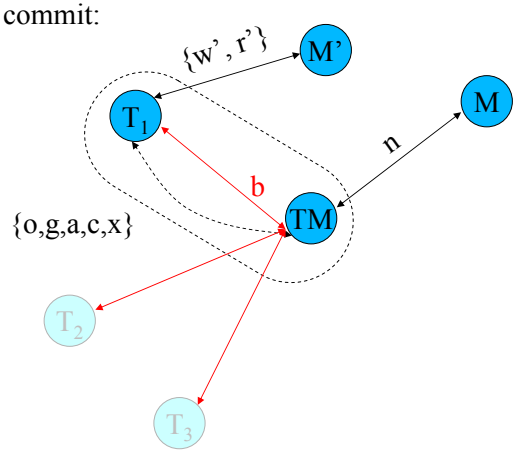
Transactional Memory

T_1 gets it's copie of M:



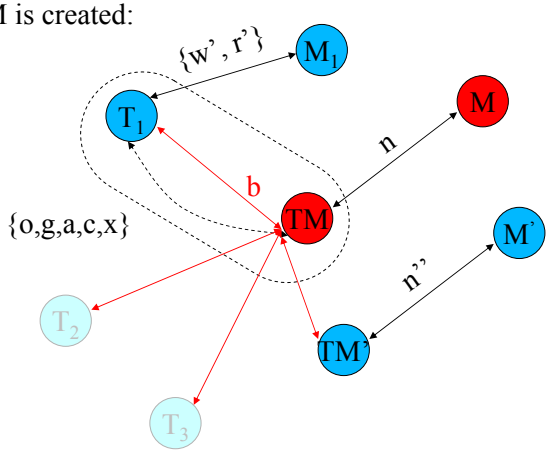
Transactional Memory

T_1 tries to commit:



Transactional Memory

A new TM is created:



Concurrent Commit

$T_1 : \underline{c_1}.(c_1 + x_1.T_1\langle b\rangle)$

$T_2 : \underline{c_2}.(c_2 + x_2.T_2\langle b\rangle)$

$TM : \underline{crash} \mid !... \mid k.\underline{x_1} \mid k.\underline{x_2} \mid ! \; p(x).k.\underline{x} \mid$

$c_1.crash.n_1'(w'',r'',n'').(TM\langle b,n''\rangle \mid !\underline{k} \mid \underline{c_1}) \mid$

$c_2.crash.n_2'(w'',r'',n'').(TM\langle b,n''\rangle \mid !\underline{k} \mid \underline{c_2})$

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T_1 : $\underline{c_1}.(c_1 + x_1.T_1\langle b\rangle)$

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TM : $\underline{\text{crash}}$ | !... | $k.\underline{x_1}$ | $k.\underline{x_2}$ | ! p(x).$k.\underline{x}$ |

$c_1.\text{crash}.n_1'(w'',r'',n'').(TM\langle b,n''\rangle | !\underline{k} | \underline{c_1})$ |

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$c_2.\text{crash}.n_2'(w'',r'',n'').(TM\langle b,n''\rangle | !\underline{k} | \underline{c_2})$

Exceptions Enhancement

- Avoiding Unnecessary Exceptions

TM := (… | !p(x,cancel).(k.$\underline{x}$ + cancel))

G := … (νcancel)($\underline{p}\langle x,\text{cancel}\rangle$. … .(… | cancel.!k)

- Allowing Needed Exceptions

Commit while Starting

T_1 : $\underline{c_1}.(c_1 + x_1.T_1\langle b\rangle)$

T_2 : $\underline{b}\langle o_2,g_2,a_2,c_2,x_2\rangle.\underline{o}.g$ …

TM : $\underline{\text{crash}}$ | !... | $k.\underline{x_1}$ | ! p(x).$k.\underline{x}$ |

$c_1.\text{crash}.n_1'(w'',r'',n'').(TM\langle b,n''\rangle | !\underline{k} | \underline{c_1})$ |

$b(o_2,g_2,a_2,c_2,x_2).p\langle x_2\rangle.o$ …

Commit while Starting

$T_1 : \underline{c}_1.(c_1 + x_1.T_1<b>)$

$T_2 : \underline{b}<o_2,g_2,a_2,c_2,x_2>.\underline{o}.g \ldots$

$TM : \underline{crash} \mid !\ldots \mid k.\underline{x}_1 \mid !\ p(x).k.\underline{x} \mid$

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$b(o_2,g_2,a_2,c_2,x_2).p<x_2>.o \ldots$

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