Transacted Memory for Smart Cards

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Overview

- What is transacted memory?
- Combining Z, Promela (SPIN) and C
- Conclusions

Java Card transactions

- atomic updates
- audit trail
- limited resources
  (64KB ROM, 64KB EEPROM, 2KB RAM)
- Java Card logs previous value

Transacted memory – abstract

Before	After
tag 1, gen 2	unused
10£, Feb 3, 2001	
tag 1, gen 3	tag 1, gen 3
80£, Feb 5, 2001	80£, Feb 5, 2001
unused	tag 1, gen 4
	70£, Feb 8, 2001
tag 5, gen 1	tag 5, gen 1
10 Downing street	10 Downing street

Write, commit and verify:

```
info = { 70£, Feb 8, 2001 };
tag = 1;
Write( tag, info );
Commit( tag );
assert( DRead( tag ) == info );
```

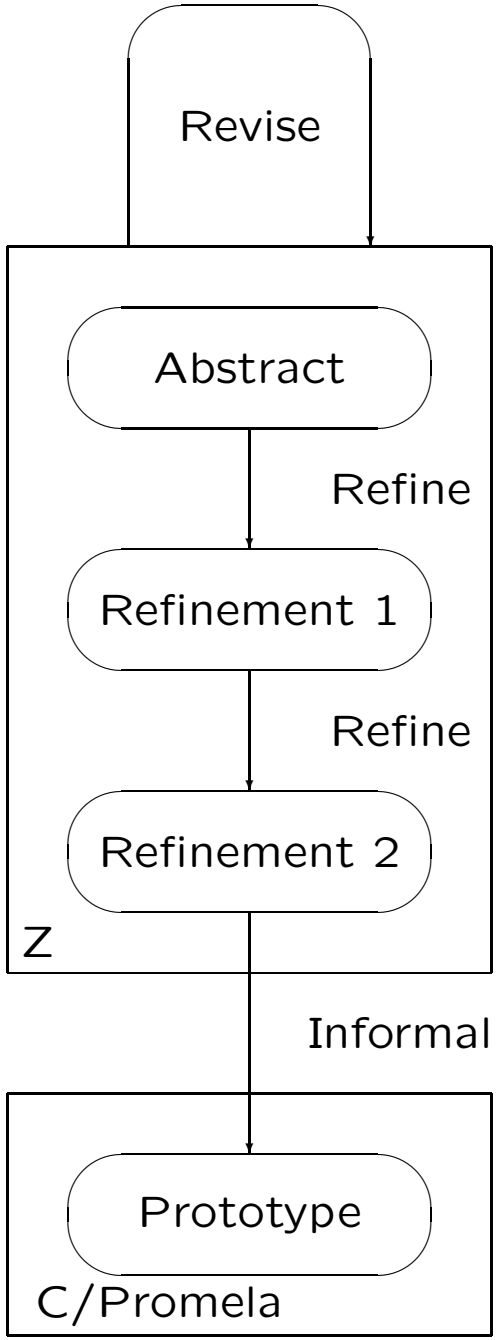
Transacted memory – concrete

Before	After
unused	tag 1, gen 4, page 0
	70£
tag 1, gen 4, page 2	tag 1, gen 4, page 2
2001	2001
tag 1, gen 4, page 1	tag 1, gen 4, page 1
Feb 8	Feb 8

Write:

info = { 70£, Feb 8, 2001 };
tag = 1;
Write_page(tag, 2, info[2]);
Write_page(tag, 1, info[1]);
Write_page(tag, 0, info[0]);

Methodology



Functions in C and Promela

Function

```
byte NewTag(byte size) {
   byte tag;
   ...
   return tag;
}
```

Call

```
byte tag = NewTag( 3 );
```

Promela: Non-deterministic choice

```
proctype NewTag() {
byte size, tag;
....
go?MSize,size ->
.....
if
:: done!Mabort; ...
:: done!MTag,tag; ...
fi
```

```
 byte tag;
go!MSize,3;

if
:: done?Mabort -> ...
:: done?MTag,tag -> ...
fi
```

Test program

- 2000 page writes
- 65 aborted writes
- No failed assertions

Issues – Z

- Non-standard constructs

$$
\begin{array}{|l}
\mathit{PROCEDURE} \\
\mathit{release} : \mathit{Memory} \times \mathbb{P}\, \mathit{Loc} \rightarrow \mathit{Memory} \\
\mathit{release}(\mathit{mem}, \mathit{lset}) = \\
\qquad \mathit{FOR\ l\ IN\ lset\ DO\ write}(\mathit{mem}, l, \ldots)
\end{array}
$$

- Syntax and typing problems, e.g.
  $a \times b$ instead of $a * b$

- 10 issues in 2 pages

Issues – Promela/C

- Typing problems, missing definitions
- Committed write does not commit
- Uncommitted pages not released
- Data may be committed twice

Conclusions

- Using non-standard Z does not help
- Z good for abstract
- Promela good for concrete
- ad-hoc common notation
- Prototype is RAM space efficient
- Time efficient with HW support?

More work on Transacted Memory

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Using **JML** & **Java** instead of **Z** & **C**:

- translation of abstract Z spec to JML
- translation of C implementation to Java

Both relatively straightforward.

JML vs Z specification

– Z easier to read than JML

\+ JML spec can easily be made executable

Java vs C implementation

– C closer to realistic machine-code implementation

\+ Java implementation of enumerations as classes
revealed bug
(but is clumsy; type-safe enums would be nicer!)

\+ Java's exception mechanism enables
realistic test scenarios, including card tears

```
public Tag NewTag(byte size) throws CardTearException {
          ...
 }
```

Java & JML vs Z & C

\+ abstract JML spec and concrete Java implementation
in the same language (namely Java)

Future work: relating abstract spec and implementation