


Patterns for Small Machines

OT2000 Tutorial 144
Using Objects in Systems with
Limited Memory



Presented by: Charles Weir
Co-author: James Noble

Small Memory Software

- There will always be niches for small memory software!
 - Mobile phones, palmtops
 - Embedded or Intravenous systems
 - Backwards compatibility
 - Small machines are cheaper
 - less memory to pay for
 - Running 1000 sessions in a 1 GB server
 - 1M per program is a small machine

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Overview

- **Fixed Data Structure**
- Partial Failure
- Multiple Representation
- Packed Data

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The StrapItOn System

- A portable, wrist-mounted PC
- Cheap, low power, fully functional
- **But: Only 1M memory (+ 2M Rom)**
- O/S functions (persistent storage, communications, internet, I/O)
- Application programs?
- Will the software fit the space available?



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StrapItOn Priority Messages

- StrapItOn can receive high priority messages via cellular network
- These messages are short (~ 100 characters)
- The messages do not arrive often
- Priority Messages must be processed quickly and reliably
- Failure to handle a message is unacceptable

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Priority Messages Resolved

- After consultation with users and PMS protocol designers, the StrapItOn developers agreed:
- Messages would be strictly limited to 128 8-bit characters
 - Excess characters can be truncated
- The StrapItOn wristtop needs to store only five messages at any given time
 - When a new message arrives, the oldest message can be deleted.
- Messages stored in an 5 x 128 char array
- Circular buffer overwrites oldest message

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Many other examples

- Mobile phone emergency handling: 911
- EPOC fixed sized string class Tbuf<int>
- Real time systems:
 - E.g. Nortel Smalltalk Telephone Exchange
- 80-col punched cards
- DOS 8.3, UNIX 14-char filenames
- DOS Buffers=
- Windows Notepad, Phone Dialler
- FORTRAN and COBOL

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Fixed Data Structure

How can you always have enough memory?

- Memory failure is unacceptable
 - in particular kinds or parts of systems

Allocate fixed structures, avoid dynamic allocation.

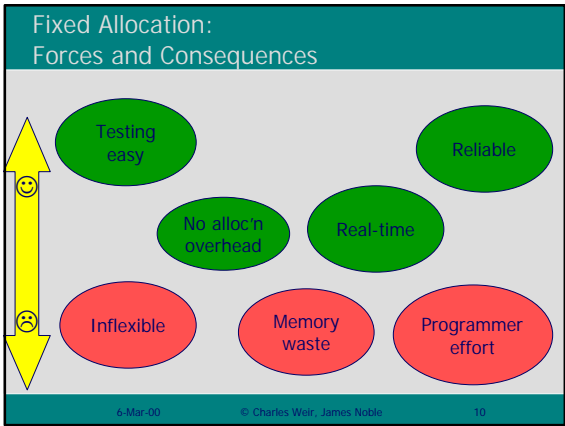
- Allocate enough space to store everything you need
- Keep it unused until it is needed
- Use static arrays, circular buffers, tables...

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Hey – this is a pattern...

<ul style="list-style-type: none">■ A pattern is a<ul style="list-style-type: none">■ <i>Solution</i> to a■ <i>Problem</i> in a■ <i>Context</i> with a list of■ <i>Related Patterns</i>■ Every pattern has a<ul style="list-style-type: none">■ <i>Name</i>	<ul style="list-style-type: none">■ Also includes:<ul style="list-style-type: none">■ <i>Forces</i> the pattern resolves■ An <i>Example</i>■ <i>Consequences</i> of using the pattern■ At least three <i>Known Uses</i>
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Implementation

- In C++, use static allocation to create an array of objects
- In Java or Smalltalk, pre-allocate objects when the program starts, and store in Singletons, static variables, or class variables
- In C or C++, be very careful not to overflow the array bounds
- In any language, handle overflows
- Record the size of the structure in a CONSTANT
 - or in C++ use `sizeof()` to access it

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Handling Overflow

Fixed User Interface – let users see just the available memory

Deferring Requests – avoid reading a new object until memory is available

Reducing Quality – keep just as much of an object as you can

Fail older requests – trash the oldest object


Fuggedaboutit – delete the new object

Signal an error – dialog boxes, exceptions, often this can be handled higher up in the system, but can be lots of work,

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Short Exercise

- Tacky-Tek's 'ClickTing' CameraPhone
 - Cheap mobile phone plus digital camera
 - 2 Mb of RAM, 300*300 pixel color screen
 - Text UI, Serial connection
- Memory budget?
 - Core Java OS: 100K
 - Phone SW: 75K
 - Mail application: ???
 - Screen RAM: ???
- How do we make it usable despite the small memory?



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Partial Failure: An example

- EPOC: uses RAM for both file system and process memory
 - So users may use up all the RAM
 - So memory allocation may fail at any time
- Can't afford to have applications lose all their data whenever allocation fails.
 - So can't terminate process on alloc fail
 - And even saving to disk might need allocated memory...

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Therefore: Partial Failure

- Any operation that can fail, may revert to a safe state
- Failure **never** causes lost data
 - At worst, user may have to free some memory in order to continue
- Some applications (e.g. EPOC Word) support 'failure modes', with reduced performance or display.

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Examples

- PalmOS uses the same principle
- MS Windows Applications' degraded modes:
 - Netscape/Powerpoint using default fonts
 - Powerpoint omits images
 - Photoshop stops saving 'undo' information
- Operating systems: fail one process; system and other processes continue.
 - UNIX, MS Windows NT, etc.

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Partial Failure Pattern

- *Allow the system to fail to a safe state*
- Abort the task that used the memory
- Or continue in a degraded mode.
- Localise the failure as far as possible

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Forces and Consequences

- Can't banish heap exhaustion
- Tasks may fail independently of others
- Users don't always need perfection...

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Implementation: Exceptions

```

main() {
  try { foo(); }
  catch (Exception e) { ... }
}

foo() {
  bar();
}

bar() {
  throw new Exception("hello");
}
    
```

- Task as a single function.
- Mechanisms to clean up stack resources

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Implementation: Larger tasks

- Task object (common in C++)
 - Object deleted or state set to 'failed'
- Task thread (easy in Java)
 - Exception terminates the thread
- Failure Modes
 - Part of the state of a large task object
 - e.g. Telephone call 'failed' state, word processor 'can't display' mode.
 - May be transient

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Overview

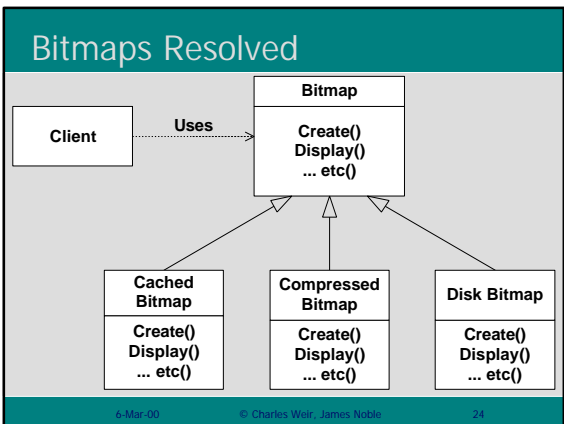
- Fixed Data Structure
- Partial Failure
- **Multiple Representation**
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Bitmaps

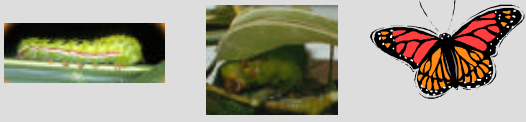
- Consider an object representing a bitmap read from a file
- How do we store it?
 - as a bitmap ready to “bitblt” to the screen?
 - as a compressed version?
 - as a reference to its representation in a file?
- Any of these may be correct, depending on how short of memory we are.

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More examples

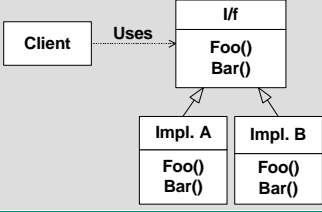
- Psion Series 5 Word Editor
- Rolfe and Nolan's Lighthouse: The Deal class
- Early IBM Smalltalk collection classes



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Multiple Representations

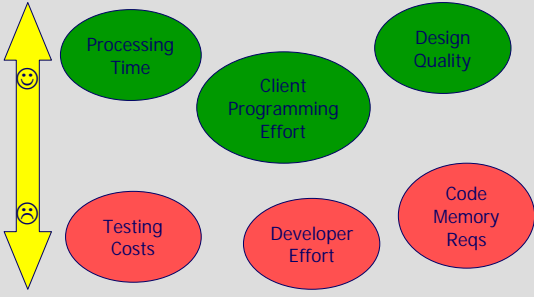
- Common abstract interface
- Clients don't worry about implementation
- E.g.



```
graph TD; Client[Client] -- Uses --> I_f["I/f  
Foo()  
Bar()"]; I_f <|-- Impl_A["Impl. A  
Foo()  
Bar()"]; I_f <|-- Impl_B["Impl. B  
Foo()  
Bar()"];
```

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Forces and Consequences



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The Insaniphone application


- The 'Insani-phone' telephone directory
- Stores a local Telephone Directory
 - Names and numbers
 - 200,000 subscribers



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Insaniphone Resolution

- Pack the data:
 - 32 area codes: 5 bits
 - Seven-digit decimal number: 24 bits.
 - Store each surname once (30,000 unique names): 18 bits for pointer
 - Three initials (5 bits each): 15 bits.
- I.e Only 4 bytes each entry (800Kb)
- Storing names at 5 bits per char: 200Kb




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More Examples

- Bit array classes: BitSet in both Java and C++ STL
- Y2K !
- EPOC String classes packs the class identifier in the length word.

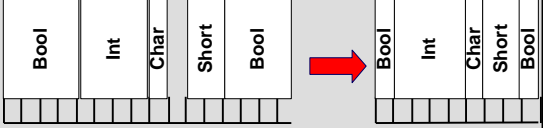
```
class TDesC8 { private: unsigned int iLength:28; unsigned int iType:4;
```
- Reuters IDN Marketstream uses bit packing and string compression to transmit Exchange prices and news.



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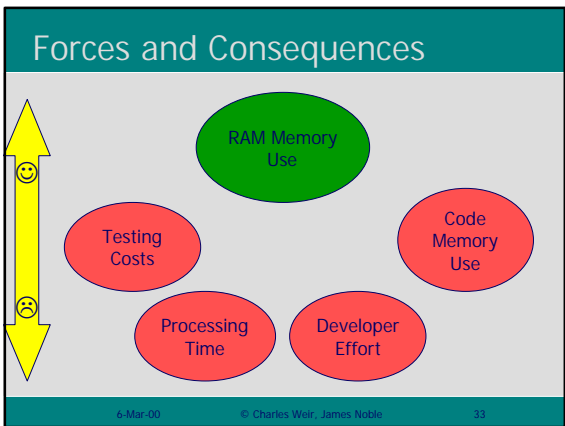
Packed Data Pattern

- Pack the data within each object
 - 'Optimise memory use' compiler flag
 - Smaller data members
 - Bytes, bitfields.
 - Arrange data structures to save padding



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Forces and Consequences



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Summary

- Several important patterns for small machines:
 - Fixed Data Structure
 - Partial Failure
 - Multiple Representation
 - Packed Data

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See Also

- Book: Small Memory Software
 - In Draft Form:
<http://www.cix.co.uk/~cweir/>
- Summary paper
 - Proceedings of the Memory Preservation Society.

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