AdaCore
The GNAT Pro Company

Safety, Security, and OOP: Inheritance, Dynamic Binding, Testing

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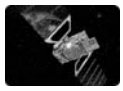
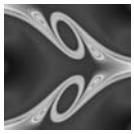
Safety & Security





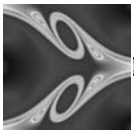


Software Technologies



chaos

Software Technologies



SP

SP = structured programming

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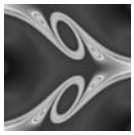

SP

OOP

OOP = object-oriented programming

chaos

Safety & Security Standards

- **DO-178B / ED-12B (Airborne SW)**
- **DO-278 / ED-109 (Air Traffic Management)**
- **IEC 61508:1999 (Trains, control machinery, …)**
- **ISO/IEC 15408:2005 (Common Criteria)**
- **DEF-STAN 00-56**
- **…**

Have not much to say about OOP vs. SP

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Up to Now ....

Most "safe & secure" software has used SP ...

- **... with some trying OOP**

Things are changing rapidly

- **Companies want to explore the of use OOP**
- **OOTiA (Handbook published October 26, 2004)**
  - Object-oriented Technology in Aviation
  - http://www.faa.gov/aircraft/air_cert/design_approvals/air_software/oot/
- **DO-178C due 3 years from now (or so)**

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DO-248: SP vs. OOP

DO-248 (2001 - clarification of DO-178B) – 3.32:

- Avoidance of non-determinism: Non-determinism may be reduced through one or more of the following practices:
  1. Choose a language with a well-defined standard.
  2. Do not permit self-modifying code.
  3. Minimize memory paging and swapping.
  4. Avoid use of dynamic binding, memory allocation, and memory deallocation.
  5. Do not assume initial values for variables that are not explicitly initialized.
- Avoidance of complexity: Complexity may be reduced through the following practices:
  1. Maximize cohesion; minimize coupling.
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  3. Use a single point of entry and exit for subprograms.
  4. Minimize use of interrupt-driven processing.
  5. Minimize use of multi-tasking/multi-processing in the architecture.
  6. Beware of side effects in the use of built-in functions and compiled libraries.
  7. Control the class library depth (inheritance tree depth).

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DO-248 In a Nutshell

- **Feel free to use OOP**
- **But be careful at what OOP features you use**
- **And at how you use them**

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DO-248 In a Nutshell

- **Feel free to use OOP**
- **But be careful at what OOP features you use**
- **And at how you use them**

Feel free to eat the pie as long as there is no intake of fat

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That is a reasonable approach

- **Use static OOP in safety/security-critical SW**

- **See SPARK (http://sparkada.com)**

SPARKAda
Praxis High Integrity Systems

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Coupling

- **Control coupling**
  - The manner or degree by which one software component influences the execution of another software component
- **Data coupling**
  - The dependence of a software component on data not exclusively under the control of that software component

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SP vs. OOP

Types	Operations					
	op1()	op2()	op3()	op4()	op5()	op6()
A	X		X		X	
B	X	X		X		X
C	X	X	X			X
D		X	X		X	

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SP: A centralized view of SW

A subprogram

Types	Operations					
	op1()	op2()	op3()	op4()	op5()	op6()
A	X		X		X	
B	X	X		X		X
C	X	X	X			X
D		X	X		X	

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OOP: A distributed view of SW

A class

Types	Operations					
	op1()	op2()	op3()	op4()	op5()	op6()
A	X		X		X	
B	X	X		X		X
C	X	X	X			X
D		X	X		X	

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OOP: A distributed view of SW

Does this chopping increase coupling?

Types	Operations					
	op1()	op2()	op3()	op4()	op5()	op6()
A	X		X		X	
B	X	X		X		X
C	X	X	X			X
D		X	X		X	

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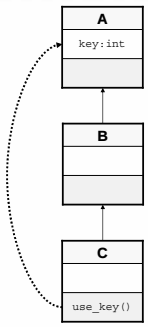
An example of what can go wrong



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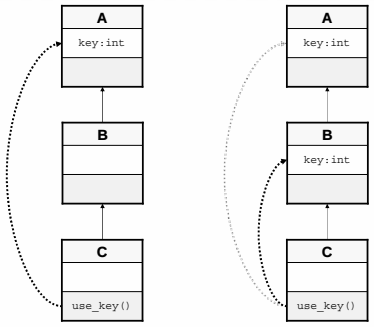
An example of what can go wrong



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Overloading

- **Overloading is a fundamental part of OOP**
- **When you mix inheritance and overloading**
- **You get a powerful and explosive mix**
- **Which can lead to serious hazards in a safety & security context**

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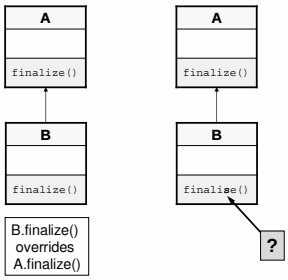
An example of what can go wrong



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A Possible Solution ….

Ada 2005

- **No hiding of field names along a derivation chain**
- **Developer can state whether a method**
  - does **override**
  - does **not override**
  - the corresponding method in the ancestor

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The Challenges of Dynamic Binding

- **Control coupling (e.g. re-dispatching)**
- **Implementation issues: safety & security**
- **Code coverage and testing**

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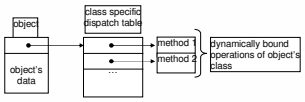
Implementation of Dynamic Binding



- **Correct initialization?**
  - Dispatch tables
  - vtable pointers
- **No unintentional / malicious modification?**
  - Dispatch tables
  - vtable pointers
- **Source-based tools?**
  - Implementation invisible at source level

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A Possible Solution

In secure / safety-critical contexts

- **The compiler could implement dynamic binding**
- **With (visible) case statements**
- **This can only be done at bind time**
- **When the entire hierarchy is available**

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Testing under Dynamic binding

- **M : number of virtual methods in the program**
- **D : number of dispatching calls**

Two extremes

Code coverage — **Test coverage**

O (M + D)

Case statement
per virtual method signature

???

O (D × M)

Case statement
per dispatching call

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Who is looking at these issues

- **DO-178C (http://ultra.pr.erau.edu/SCAS/)**
  - SC-205 / WG-71: SG5: Object-Oriented Technology
- ***ISO/IEC Project 22.24772: Guidance for Avoiding Vulnerabilities through Language Selection and Use* (http://www.aitcnet.org/isai/)**
  - SC 22