Computer Science Program, The University of Texas, Dallas

Abstract Data Types (ADTs)

Why ADTs?

Main Concepts of ADTs

ADTs as Objects

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Why Abstract Data Types (ADTs)?

Why Module Interconnection Languages (MILs)?

"Programming-in-the-small vs. programming-in-the-large"

	Programming-in-the-small	*Programming-in-the-small*
Goal	building "programs"	building "software"
Problem	Usually clear, small	Usually unclear, large
Emphasis	Detailed design & impl.	sw. architecture
Technique	Structured programming	"divide & conquer" "separation of concerns"
Notation	PLs	(Formal) (OO) Specification Lang.
Manpower	single person/small number	multi-person
Version	usually single	multi-version

interface-oriented

- **hiding the representations**
  localized change: change in detailed design & impl. does not affect other (client) objects
- **specifying the representations**
  conceptual consolution
- **conquering complexity**
  decomposing problems into collections of interacting components (-> encapsulation)

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Main Concepts of ADTs

- ***model system as a collection of ADTs***
  - algebraic specification
  - model-theoretic (axiomatic) specification -> Z
- ***Larch is for Algebraic Interface Specification***

  ["Larch: Languages and Tools for Formal Specification",
  J. V. Guttag, J. J. Horning, S. J. Garland, K. D. Jones, A. Modet & J. M. Wing,
  Springer-Verlag, 1993]
- ***Each ADT includes:***
  - data objects
  - operations on data objects
    (specified as functions with domain and range)
  - essential properties of operations algebraic equations in FOL with equality
    (specified in algebraic equations in FOL with equality)
- ***Two-tiered approach to software development***
  - LCL - Larch Common Language

    PL-independent notation for writing interface spec.
  - LSL - Larch Shared Language

    PL-dependent notation for writing interface spec.
    LSLs exist for SmallTalk, Modula-3, C, C++, CLU, ...
- ***large library of predefined specs for common data types***
- ***Larch theorem prover for correctness of properties***

Main Concepts of ADTs

- **Example**

```
                                  /* A trait describes an ADT, i.e., data objects, ops, properties of ops
Stack (E, C): trait                  & links to other ADTs */
                                  /* E is an element (e.g., int, str, bool) of C, a container */
   introduces
        new: -> C
        push: C, E -> C
        top: C -> E exempting top (new)
        pop: C -> C exempting pop (new)
        isEmpty: C -> Bool
   asserts
        C generated by new, push
        forall stk: C, e: E
             top ( push ( stk, e ) ) == e
             pop ( push ( stk, e )) == stk
             isEmpty (new)
             ~ isEmpty ( push ( stk, e ))
   implies
        LinearContainer (push for insert, top for first, pop for rest)
```

Main Concepts of ADTs

- Questions

```
Stack (E, C): trait        /* A trait describes an ADT, i.e., data objects, ops, properties of ops
                              & links to other ADTs */
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```
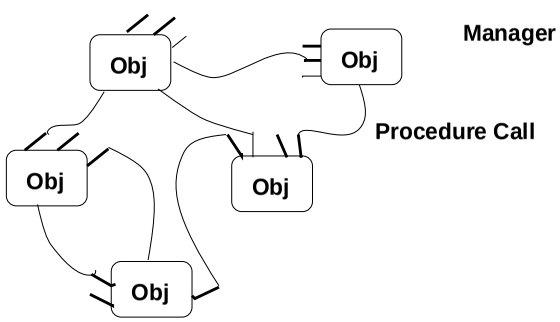

- pop (top (new)) ==
- isEmpty (pop (push (new, 5))) ==
- first (rest (insert (insert (new, 10), 11))) ==

/* Assume new for new */

ADTs as Objects

- Does Fortran/COBOL/C/Pascal offer subroutines for operations?
  Does Fortran/COBOL/C/Pascal offer information hiding?
- Objects (also called "managers") are responsible for
  - preserving the integrity of their resources &
  - hiding the representations from other objects
  - interactions take place mostly thru function and procedure invocations



- encourages reuse (<- hiding & encapsulation)
- interaction via procedure call
  - *a (client) object should know the identity of another (server) object (cf. pipe&filter)*
  - *change of an object identity necessitates modification of all other objects that explicitly invoke it*