Model-Based Specification in VDM

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Vienna Development Method (VDM)

- Formal specification languages
  - VDM-SL
  - VDM++

- Combination: model-based + algebraic
  - Abstract modeling (data + contracts)
  - Executable subset (prototyping implementation)

- Tools
  - validation, analysis, testing
  - code generation (Java, C++)
VDM-SL

- Syntax
  - ASCII text, graphical

- Features
  - Basic types: numeric, character, token, quote
  - Collections: set, sequence, map
  - Type constructors: union, cartesian product, record (composite)
  - Functions (pure, no side effects)
  - Operations (modify global state)
Example

- Management system for public transport

- Key concepts
  - Modules (import, export)
  - Implicit definition of functions/operations
    - Contracts (precondition, postcondition)
  - Explicit definition of functions/operations
    - Prototype implementation (algorithm)
  - Control-flow structures
    - imperative, functional
Proving correctness

Implicit definition
\[ f(p: T_p) r: T_r \]
\[ \text{pre} \quad \text{pre-} f(p) \]
\[ \text{post} \quad \text{post-} f(p, r) \]

Explicit definition
\[ f: T_p \rightarrow T_r \]
\[ f(p) = \ldots \]

Proof obligation
\[ \forall p: T_p \cdot \text{pre-} f(p) \Rightarrow f(p): T_r \text{ and post-} f(p, f(p)) \]
Refinement – another perspective

- Abstract data representation AR
- New concrete data representation CR
- Abstraction function $\alpha : CR \rightarrow AR$

Proof obligations

- $\forall a : AR \cdot \exists c : CR \land a = \alpha(c)$
- $\forall c : CR \cdot \text{pre-OpA}(\alpha(c)) \Rightarrow \text{pre-OpC}(c)$
- $\forall c^\sim, c : CR \cdot \text{pre-OpA}(\alpha(c^\sim)) \land \text{post-OpC}(c^\sim, c) \Rightarrow \text{post-OpA}(\alpha(c^\sim), \alpha(c))$
Tools

- **VDMTools**
  - [http://fmvdm.org/vdmtools/](http://fmvdm.org/vdmtools/)
  - Checks syntax, types, integrity
  - Interpreter (debugger)
  - Code generation (Java, C++)

- **Overture**
  - [http://overturetool.org/](http://overturetool.org/)

- [https://dl.acm.org/citation.cfm?id=94062](https://dl.acm.org/citation.cfm?id=94062)