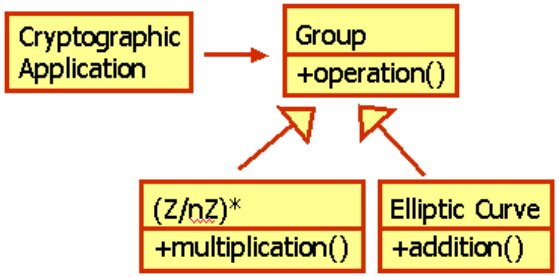
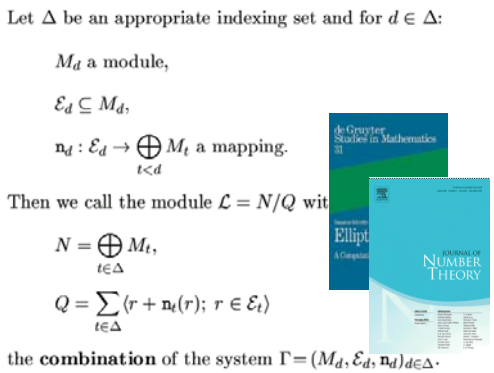
Using the Synergies Between the Object-Oriented Paradigm and Mathematics in Joint Mathematics/Computer Science Programs




Let Δ be an appropriate indexing set and for $d \in \Delta$:

M_d a module,

$\mathcal{E}_d \subseteq M_d$,

$\mathfrak{n}_d : \mathcal{E}_d \to \bigoplus_{t<d} M_t$ a mapping.

Then we call the module $\mathcal{L} = N/Q$ wit

$$N = \bigoplus_{t\in\Delta} M_t,$$

$$Q = \sum_{t\in\Delta} \langle r + \mathfrak{n}_t(r);\ r \in \mathcal{E}_t \rangle$$

the **combination** of the system $\Gamma = (M_d, \mathcal{E}_d, \mathfrak{n}_d)_{d\in\Delta}$.

Marc Conrad - Tim French

University of Luton

Mathematics and Software...

(a never ending story)

- *Traditionally software has the role of a "tool" in teaching mathematics (if at all!)*
- *There are ongoing debates if and how these "tools" can be used.*
- *We go further:*

- Object oriented software can play a crucial role in *visualising* and *understanding* of Mathematics

The Object Oriented Paradigm...

(Java everywhere)

- *Object oriented languages as Java, C++, C# are the main languages Computer Science students encounter during undergraduate courses.*
- *Students accumulate knowledge of object orientation*
- *This can be linked to Mathematics:*

- Object oriented knowledge can be used as a basis for *learning* and *teaching* of Mathematics

Axiomatic Mathematics...

(Computers and pure mathematics?)

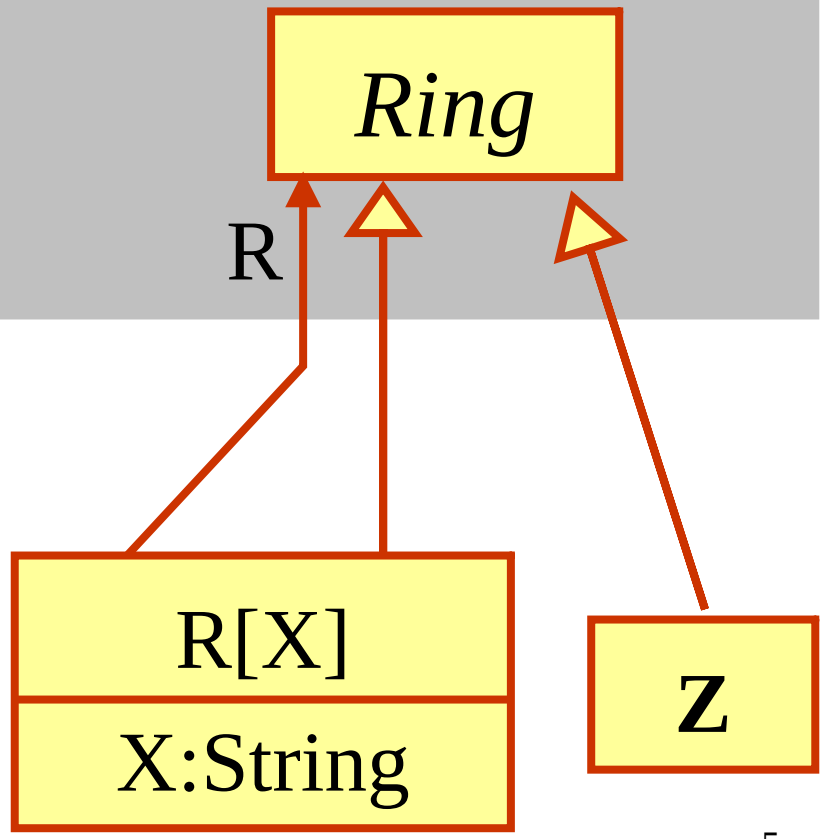
- *Mathematical software is traditionally used for number crunching, solving of equation systems, etc.*
- *"Pure" mathematics has been so far addressed only in research context (theorem proving, …)*
- *We believe that we can do better:*

- Pure mathematics can be *modelled* and *implemented* via object oriented languages as Java, C#, or C++

Abstract Structures are modelled as abstract classes.

Abstract: An arbitrary (unspecified) ring

Concrete: Ring of Integers, Polynomial Rings, …

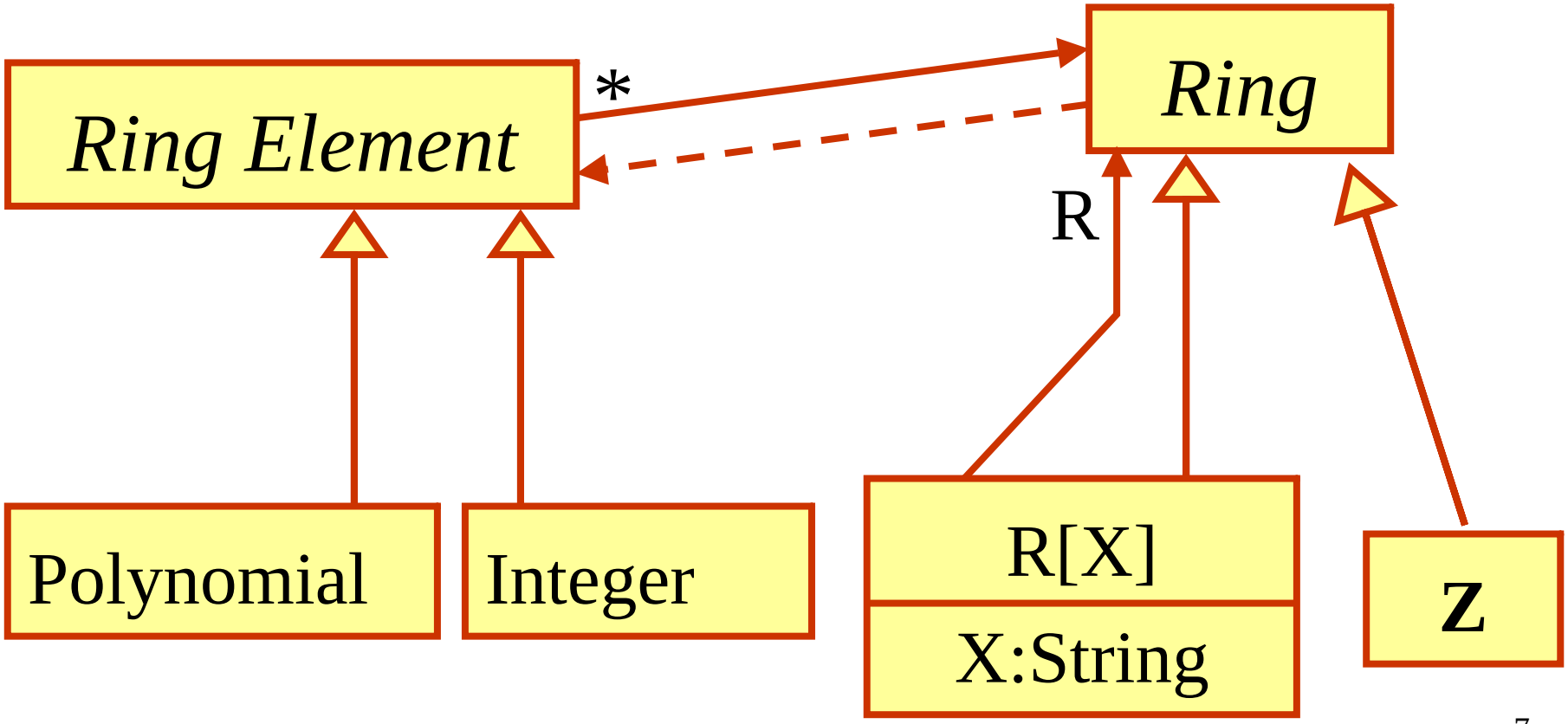


Axiomatic definitions are implemented as abstract methods.

Example: *Ring*

- Abstract:
  - addition
  - negation
  - multiplication
  - inversion
  - "zero"
  - "one"
  - check if zero
- Not abstract:
  - subtraction
  - exponentiation
  - embedding of Z and Q
  - Check for equality
  - evaluation of polynomials

Use the GoF Mediator pattern for Implementing Abstract Mathematics.



The com.perisic.ring package provides the following classes:

- Rings, Polynomial Rings, Integers, Rational Functions, Algebraic Extensions, Cyclotomic Fields, Universal Rings, etc.

The com.perisic.ring package can serve as a reference model for:

- groups, metric spaces, topological spaces, group rings, etc.

Example of student activities:

- Using the Java com.perisic.ring package as a reference model implement an abstract class *metric space* with an abstract method *distance()*.
- In the abstract class implement applications (e.g. closest two points,…)
- Implement child classes: *points on a plane*, *three dimensional space*, $\boldsymbol{F}_2^n$,...

Further Reading

- The Java package com.perisic.ring is available at: http://ring.perisic.com
- M. Conrad, T. French, *Exploring the synergies between the Object-Oriented paradigm and Mathematics: A Java led approach*, to appear in Int. J. Math. Educ. Sci. Technol.
- M. Conrad, T. French, C. Maple, S. Pott, *Mathematical Use Cases lead naturally to non-standard Inheritance Relationships – How to make them accessible in a mainstream language?*, MASPEGHI 2004 (WS 12 of ECOOP)

Contact

- Marc Conrad
  - *marc.conrad@luton.ac.uk*
- Tim French
  - *tim.french@luton.ac.uk*

University of Luton
Dept. of Computing and IT
Park Square
Luton LU1 3JU
United Kingdom