Domain Engineering with Concepts

Magne Haveraaen
& Sophus Group

Bergen Language Design Laboratory (BLDL)
Department of Informatics, University of Bergen, Norway

Workshop on Concepts, Bergen, November 5, 2009

Domain Engineering

Turning concepts into types and operations

- What are the concepts of a domain

- What is the language we use to express these concepts

- What are the types and operations in this language

- What are the properties of the operations

Story from the trenches: PDE domain

Mathematicians talk about

- Vector - 1-indexed array of reals
- Matrix - 2-indexed array of reals
- changeBasis: Matrix, Vector -> Vector
- dot: Vector, Vector -> Real,
  - dot(u,v) = u[0]*v[0] + ... + u[n-1]*v[n-1]

Me:

- dot(u,changeBasis(M,v))
- dot(changeBasis(M,u),changeBasis(M,v)) =
  - changeBasis(M,u)[0]*changeBasis(M,v)[0]+...+...

Story from the trenches: PDE domain

Mathematicians think

Vector<Basis> - 1-indexed array of reals in given Basis

BasisMap<F,T> - 2-indexed array of reals from F to T

changeBasis: BasisMap<F,T>, Vector<F> -> Vector<T>

dot: Vector<Basis>, Vector<Basis> -> Real

Axiom:

dot(u,v) == dot(changeBasis(M,u),changeBasis(M,V))

Sophus Concepts

Time integration

PDE equation

Tensor abstractions with Basis

- Representation: multi-indexed arrays of reals

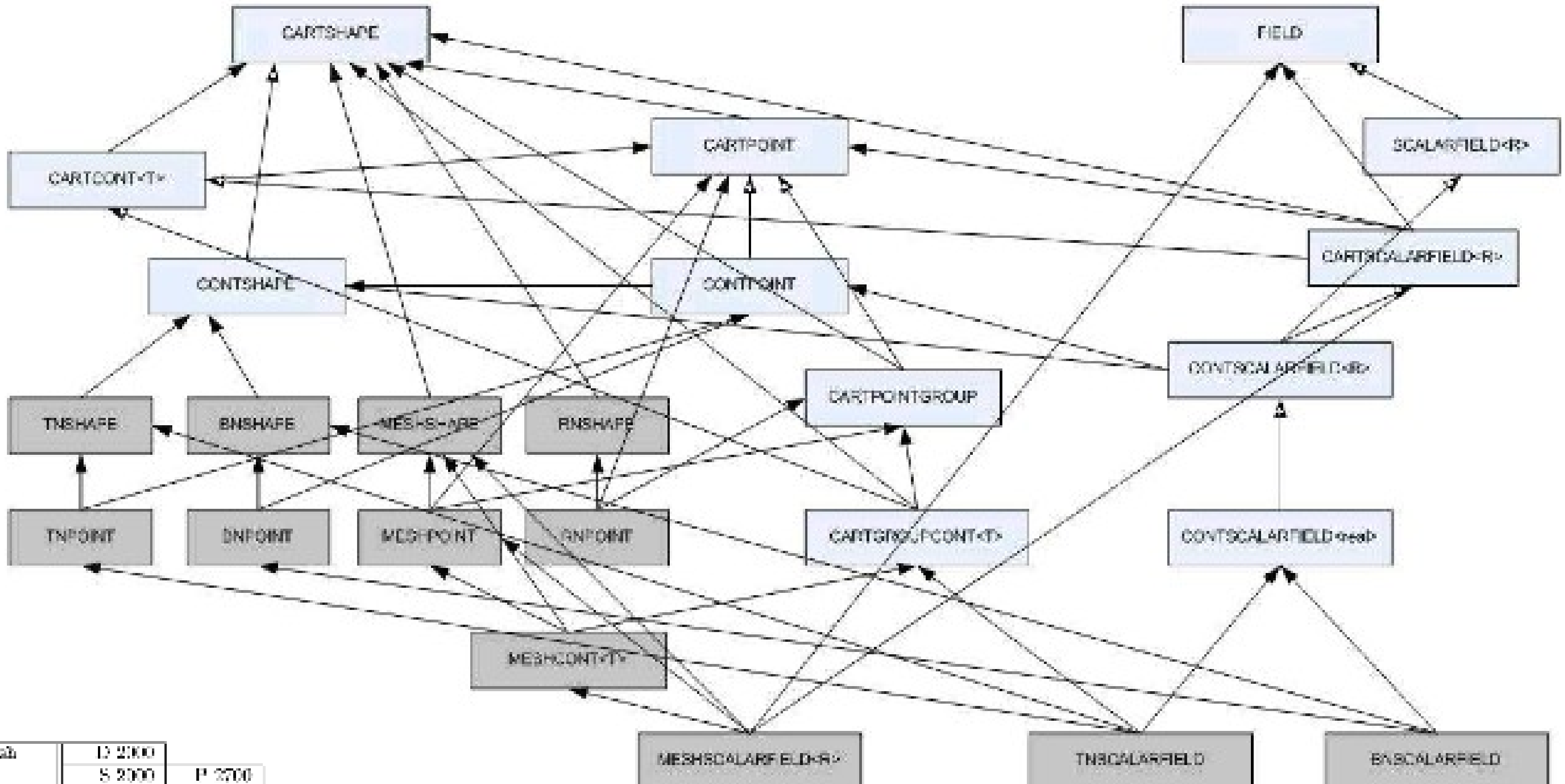
Scalar fields

- Finite Difference, Finite Element, Finite Volume, ...
- Representation: huge multi-indexed arrays of reals

Multi-indexed arrays of reals with collective operations

- Sequential layout in memory: per element operations
- Parallel distribution: element operations in parallel

Some Sophus Experience



Mesh	D 2000				
	S 2000	P 2700			
Tn	D 1700				
	SFD 1800				
Bn	D 1500				
	S 1800	P 2100			
Tensor	SI 2200	SPI 2300	STA 3000	CI 2300	CPI 2900
Seismod	SE 600	PE 700			