Formal software engineering for computational modelling
Formal software engineering

• Focus on the formal, mathematical side of software
• Ex. Algebra
• Three problems
  • What are the concepts that have to be used for the construction of software in this domain
  • What is a good programming notation for these concepts
  • How can they be implemented as software code
• Domain specific language (DSL)
• Domain specific embedded language (DSEL)
Software process model for developing DSEL

• Establish an appropriate DSL
• Validate the suggested DSL
  • Usefulness
  • Implementability
• Decide the architecture of the software library
• Design and implement a prototype
• Maintain the library
Establish an appropriate DSL

• Algebraic specification

• Ring

\[
\begin{align*}
(a + b) + c &= a + (b + c), \\
(a * b) * c &= a * (b * c), \\
(a + b) - b &= a, \\
0 + a &= a, \\
1 * a &= a, \\
\end{align*}
\]

(1) \hspace{4cm} (2) \hspace{4cm} (3) \hspace{4cm} (4) \hspace{4cm} (5) \hspace{4cm} (6) \hspace{4cm} (7) \hspace{4cm} (8) \hspace{4cm} (9)
Validate the suggested DSL

• Usefulness
  • Searching for oil
• Implementability
  • Discretization

Elastic wave equation

\[
\rho \frac{\partial^2 \ddot{u}}{\partial t^2} = \nabla \cdot \sigma + \vec{f}(t),
\]

\[
\sigma = \Lambda(e),
\]

\[
e = \mathcal{L}_{\ddot{u}}(g).
\]
Software architecture

- How to arrange different concepts
- Mesh (S or P)
- Scalar fields (Discretization)
- Tensors (coordinate system)
# Results

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