Co-Configuration of Products and On-Line Service Manuals

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Outline

- **Complex Products:** SIEMENS Magnetic Resonance Tomographs
- **Complex Service Manuals:**
  - Have to cover all product instances
  - Complicated maintenance procedures
- **Goal:** Each manual individually configured for each product instance
The Product: Magnetic Resonance (MR) Tomographs

- 11 basic MR systems (model lines):
  - Concerto, Symphony, Harmony, …

- Total of 47 configurable component types, e.g.:
  - 14 different gradient power amplifiers
  - 82 different coils (for examination of different parts of the body)
  - 9 different gradient coils
  - 20 service-software add-ons
  - 2 railway mains frequency EFIs
  - 45 destination countries (e.g. India, Czech Republic, …)
  - …
MR Product Structure

- Product structure translatable into propositional logic formula $F$
- Configuration option $\equiv$ propositional variable
- Valid configuration $\equiv$ model of formula $F$
The Manuals: Split into HelpPackages

- Each manual configured individually for each product instance
- Manuals composed of smaller handbook fractions (*HelpPackages*)
- Additional specification (*HelpContexts*) indicates what makes a complete product manual
Product Manuals: Example

**Manual 1**

**For Product Instance:**
System=Harmony, MPCU=300MHz, Receiver=R-4, Rx4=X-2,...

- HelpPackage 1: Introduction
- HelpPackage 3: QA Harmony
- HelpPackage 4: Tune-Up Harm.
- HelpPackage 5: Magnet Cooling
- HelpPackage 8: Backup&Rest.

**Manual 2**

**For Product Instance:**
System=Concerto, Table=Open, SAR=IEC,...

- HelpPackage 1: Introduction
- HelpPackage 2: QA Concerto
- HelpPackage 7: Tune-Up Conc.
- HelpPackage 5: Magnet Cooling
- HelpPackage 8: Backup&Rest.
- HelpPackage 10: Dicom Tests
Automatic selection of appropriate packages based on *dependencies*. 
Consistency Issues

- Are the manuals complete?
  Or are there missing pages/sections?

- Are there ambiguities in the manuals?
  I.e. more than one help package for a certain topic

- How are these issues resolved?
  - Translation into propositional logic satisfiability / validity problem
  - Generated problems solved by SAT-solver / Binary Decision Diagrams (BDDs)

⇒ HelpChecker
Consistency Checks with the HelpChecker

Product Structure In XML

Help Package Assignment In XML

Propositional Encoding of Prod. Struct.

Propositional Encoding of Assignment

HelpChecker

SAT Solver / BDD Package

Result of Consistency Check (Overlaps / Holes)

[For details on propositional encoding see our ICFEM 2004 paper.]
Implementation & Experimental Results

- *HelpChecker* is part of a larger authoring tool
- MR product structure and help packages stored in XML data base, *HelpChecker* implemented in C++
- Propositional encoding of product structure results in:
  - 1425 propositional variables, 11018 clauses (CNF SAT encoding), 9715 formula nodes (BDD)
- Run-time for complete check:
  - ~50s (on 3 GHz Pentium 4 with 1 GB Memory)
  - 4 model lines, 3871 help contexts, 928 help packages
SIEMENS
Authoring System GUI
Summary

- Modular handbooks for complex products are feasible
  - Can be generated automatically out of a set of handbook fractions (HelpPackages)
  - HelpPackages are annotated with propositional logic formulae to indicate associated product instances

- Exact semantics (translation of XML terms into propositional logic) enables automatic consistency checks
  - Automated reasoning techniques (SAT-Solvers, BDDs) sufficiently advanced