Model Checking the Palliative Care Process

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What is Model Checking?

- MC is the process of verifying that a given model satisfies a given set of properties
- Properties are given in Linear Temporal Logic (LTL) or Computation Tree Logic (CTL)
- The model is specified in a modelling language such as SMV or DVE.

CTL

Branching temporal logic

- Path operators:
 - Universal (A)
 - Existential (E)
- State operators:
 - Global (G)
 - Future (F)
 - Next (X)
 - Until (U)



Ex: AG(doorOpen → ~heat)

LTL

- Linear in time no branching
- No path operators
- State operators are the same as CTL

Example:

G(orderPlaced → F(orderServiced V coupon))

Problems

- State Explosion
 - Memory requirements can quickly make verification intractable
- Time Consuming
 - Writing the code for the model checker can be like re-writing the entire project!
- Tedious

Healthcare

The Problem

- Healthcare documentation needs to be improved
 - Forms
- Information needs to be shared quickly and accurately
 - EHR
- Communication protocols need to be updated
- Overall coordination of careflow needs to be refactored

The Problem (continued)

- Complexity!
- 24 forms for PC alone
- Palliative Care workflow has approx. 275-300 unique tasks in 37 subnets
- Approximately 40 different decision points



Goals

- Agent-based architecture for communication and coordination of the care providers and patient
- Implement monitors to ensure rules are satisfied
- Build decision support through ontologies of medical terms
- Employ access control methods to privacysensitive patient data

Palliative Care Workflow Verification

Tools Used

- Yet Another Workflow Language (YAWL)
- XML Schema
- DiVinE (Model Checker)
- Eclipse (Java IDE)
- NovaFlow (Eclipse Plug-in)

Palliative Care Workflow

ACTION	WHO	TIMELINE
PRE-TASKS		
Patient has initial visit consult	Palliative Nurse Consultant/Coordinator	When patient has been accepted into Palliative Care program
4-page assessment is completed (see PC-021-NR- Hospice PC 4-pg Assessment-GSH- 20100101)	Palliative Nurse Consultant/Coordinator	Concurrent with above
TASKS		
Patient and/or family member visit could be Palliative Nurse Consultant/Coordinator and/or Physician to client home client home client to clinic or Palliative Nurse Consultant/Coordinator office family member to Palliative Nurse Consultant/Coordinator office	Palliative Nurse Consultant/coordinator; Physician Consultant; Patienţi Family Member (or other person with similar status)	Ongoing
form is completed	Palliative Nurse Consultant/Coordinator and/or Physician Consultant	 Some things documented during visit (e.g., tick off areas, vital signs, medications) Some things are documented immediately after (e.g., summary of patient condition)
Copies are distributed appropriately Note: 4 copies could be distributed to Medical Records (in	Palliative Nurse Consultant/Coordinator	Once form is completed

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- Translate workflow documents into YAWL specifications
- Translate forms into XML Schema
- Port YAWL specification to NovaFlow

Model Checking

- Use NovaFlow's built-in translation to DVE
- Reduce the model w.r.t. a given property to be checked
- Update the system until the property is satisfied, and use this information to improve the healthcare workflow

Healthcare Standards and Norms

- Full documentation of professional standards for the health care system
- 52 norms total, divided into 6 categories
 - Assessment
 - Information Sharing
 - Decision Making
 - Care Planning
 - Care Delivery
 - Confirmation

Example Properties

- If a patient is evaluated and assigned a Palliative Performance Scale (PPS) value of 50% or less, then that patient is moved to the hospital.
 - $G(pps_lower_than_50 \rightarrow F(patient_at_hospital))$
- If the (boolean) field "Advance Directives" on form PC-007 (Issues Log) is set to TRUE, then PC-026 (Advance Directives) must be completed.

- G(issuesLog_advDir_true \rightarrow F(advDir_complete))

Properties (continued)

- A message is re-sent every 24 hours until the recipient sends a confirmation
 - $G((24hrs_elapsed \rightarrow X message_sent) U confirmation)$
- A medication is never given which may trigger an allergy
 - G (allergy \rightarrow ~medicine_with_allergen)

Conclusion

- Workflow Specification
 - Graphical interface
- Model Verification
 - Translation to DVE
- Healthcare is a huge domain
- Palliative care is huge, but still a very small section of the big problem!