Knowledge-Based HomeCare eServices for an Ageing Europe

FIP Model v1.0: The Set Theory Approach
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Introduction

- **K4CARE (IST-2004-026968: Knowledge Based Homecare eServices for an Ageing Europe)**
- **Chronic disabled patients at home (HCP)**
- **Home Care (HC) Knowledge-based healthcare model & ICT platform**
  - Declarative Knowledge (*know what*)
    - Actor Profile Ontology (APO) to represent Knowledge on HC actors.
    - Case-patient Profile Ontology (CPO) to represent Knowledge on HCP.
  - Procedural Knowledge (*know how*)
    - **Formal Intervention Plans (FIPs)**
  - The SDA* Model v1.0
  - The SDA* Model v2.0
  - The SDA* Model v3.0
Antecedents

- Asbru
- PROforma
- EON
Antecedents I: Asbru

- **Asgaard Project** (www.asgaard.tuwien.ac.at)
- **Asbru** is Asgaard language to represent GDL and protocols in XML format.
- **Arguments** are values passed from the invoking or calling plan to the invoked or called plan.
- **Preferences** describe costs, resource constraints, and responsible actor.
- **Intentions** represent high-level goals of the plan.
- **Conditions** mediate the changes between plan states whose normal evolution is
  1) wait for plan,
  2) fulfill the filter precondition,
  3) become activated,
  4) complete plan unless abort/suspend, and
  5) terminate plan.
- **Effects** describe the possible consequences of plans.
- **Body** contains set of plans to be executed in a particular way.

**Types of plan**

- in sequence (one after the other),
- in parallel (simultaneously),
- in any order (only one at a time), and
- unordered (anyone at a time).
Antecedents II: PROforma

- www.acl.icnet.uk/lab/proforma.html
- **Plans** are basic building blocks of a GDL that may contain any number of tasks of any type, including other plans.
- **Decisions** are taken at points where options are presented, e.g. whether to treat a patient or carry out further investigations.
- **Actions** are clinical procedures, e.g. administrate an injection.
- **Enquiries** are requests for further information or data, required before the guideline can proceed.
Antecedents III: EON

- **SAGE Project** ([www.sageproject.net](http://www.sageproject.net))
- EON is about guideline modelling and execution system
- Protégé
- **Scenarios** partial characterizations of the state of a patient.
- **Action steps** sets of (instantaneous) action specifications to be carried out.
- **Decisions** choices from a set of competing alternatives.
- **Branches** concurrent action sequences.
- **Synchronization steps** concurrence becomes sequence.
- **Time point** instant time that can be
  - exact date (definite time point),
  - vague date (fuzzy time point) or
  - time with respect to the present time (e.g. “today”, “now”) (relative time point).
- **Duration** quantity of time that can be
  - definite (e.g. 5 days)
  - fuzzy (e.g. 5 days more or less).
  - **Time interval** time between two time points.

The guideline model and the temporal model interact through the concept of **criterion**
Hypertension Diagnosis and Treatment

1. Screening and identification of elevated BP and/or other risk factors in patients with diabetes, chronic kidney disease, heart failure, or CAD.

2. Confirm elevated blood pressure.

3. Complete initial assessment; evaluate, accurately stage, and complete risk assessment.

4. Is secondary cause suspected?
   - Yes: Order additional workup; Consider referral.
   - No: Lifestyle modifications + drug therapy.

5. BP at goal?
   - No: Change treatment: 1. Increase initial agent, 2. Add another agent from a different class, 3. Substitute new agent.

6. BP at goal?
   - No: Resistant hypertension?
     - No: Hypertension continuing care.
     - Yes: Hypertension consult.
The SDA* Model I: Formal Description

- **Variables**
  - State Variables
  - Decision Variables
  - Action Variables

- **Elements**
  - State
  - Decision
    - Branches
    - Otherwise branch
  - Action
    - Sort of Action
    - Actor performing the Action

- **SDA structure**
  - State $\rightarrow$ Decision $\rightarrow$ Action

- **FIPs**
  - SDA Connected Elements
  - Connectors
    - In-element
    - Out-element
  - Feasible Entry Points
The SDA* Model II: Sequences and Cycles

DECISION

STATE

ACTION

DECISION

STATE

ACTION

DECISION

STATE

ACTION

DECISION

STATE

ACTION

DECISION

STATE

ACTION

DECISION

STATE

ACTION

DECISION

STATE

ACTION

DECISION
The SDA* Model III: Non-Determinism

Patient Condition

\[ A, B, C \]

FIP

\[ \langle \{A,B,C\};\{A,B\},\{B,C\} \rangle \]

\[ \langle \{A,B\},\{A,B\},...;\{A,B\} \rangle \]

\[ \langle \{A,B\},...,\{A,B\} \rangle \]

\[ X \]
\[ Y \]

\[ \ldots \]

FIP

FIP

FIP
The SDA* Model IV: Time

- Two sort of time constraints

  - Constraint on the FIP variables (Temporal Variables)
    - \([\text{start, end, frequency}]\)
    - \(\text{Start and End: time points (ex. 9/10/2006, 1 week ago) describing an interval.}\)
    - Frequency: periodicity (ex. 24h meaning “each 24h” or 3/24h)
    - Examples:
      - \((\text{antidepressant, [9/10/2006, 16/10/2006, 24h]})\)
      - \((\text{TwoAntidepressant, [x,y,24h]})\)
      - \((\text{Antidepressant, [x,y,12h]})\)

  - Constraint on the FIP connectors (Temporal Connectors)
    - \([\text{min, max}]\)
    - \(\text{Min and Max: durations meaning delays (ex. 9h, 6 days, 3 weeks)}\)
    - Examples:
      - \([1 \text{ week, 3 weeks}]\) meaning “not before 1 week and later than 3”
      - \([- , 3 \text{ weeks}]\) meaning “not more than 3 weeks (delay)”
      - \([1 \text{ week, -}]\) meaning “not less than 1 week (delay)”
## Construction of FIP I: Abstract Data Type

<table>
<thead>
<tr>
<th>elements</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>EmptyState:</td>
<td>$\rightarrow$ STATE</td>
</tr>
<tr>
<td>InsertVariable:</td>
<td>$\text{Variable} \times [\text{TIME}]^3 \times \text{STATE} \rightarrow \text{STATE}$</td>
</tr>
<tr>
<td>EmptyBranch:</td>
<td>$\rightarrow$ BRANCH</td>
</tr>
<tr>
<td>OtherwiseBranch:</td>
<td>$\rightarrow$ BRANCH</td>
</tr>
<tr>
<td>InsertVariable:</td>
<td>$\text{Variable} \times [\text{TIME}]^3 \times \text{BRANCH} \rightarrow \text{BRANCH}$</td>
</tr>
<tr>
<td>EmptyDecision:</td>
<td>$\rightarrow$ DECISION</td>
</tr>
<tr>
<td>InsertBranch:</td>
<td>$\text{BRANCH} \times \text{DECISION} \rightarrow \text{DECISION}$</td>
</tr>
<tr>
<td>EmptyAction:</td>
<td>$\rightarrow$ ACTION</td>
</tr>
<tr>
<td>InsertVariable:</td>
<td>$\text{Variable} \times [\text{TIME}]^3 \times \text{ACTION} \rightarrow \text{ACTION}$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SDA</th>
<th>Not required at this moment as part of the basic constructors</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIP</td>
<td></td>
</tr>
<tr>
<td>EmptyFIP:</td>
<td>$\rightarrow$ FIP</td>
</tr>
<tr>
<td>InsertElement:</td>
<td>$\text{Element} \times \text{FIP} \rightarrow \text{FIP}$</td>
</tr>
<tr>
<td>InsertConnector:</td>
<td>${\text{STATE} \mid \text{ACTION}}^2 \times [\text{TIME}]^2 \times \text{Element} \times \text{FIP} \rightarrow \text{FIP}$</td>
</tr>
<tr>
<td>InsertConnector:</td>
<td>$\text{BRANCH} \times \text{DECISION} \times [\text{TIME}]^2 \times \text{Element} \times \text{FIP} \rightarrow \text{FIP}$</td>
</tr>
</tbody>
</table>
Construction of FIP II: Textual Representation

- **Id** = number identifying an element of a FIP
- **Time** = numberY | numberMO | numberD | numberH | numberMI | numbers | nil
- **TimePoint** = Time | Date | nil
- **Tvariable** = (name (timePoint timePoint time))
- **State** = (id (tvariable*) connector*)
- **Decision** = (id (branch connector)* connector*)
- **Branch** = (tvariable*) | otherwise
- **Action** = (id (tvariable*) connector*)
- **Element** = State | Decision | Action
- **Connector** = (id (time time))
- **FIP** = Element*
Construction of FIP III: Execution of FIPs

- **FIP** represents a general intervention.
- **FIP DOES NOT** represent the evolution of the patients that follow the FIP.
- Patients that follow the FIP may not evolve as the indications of the FIP.
- **FIP execution**
  - *Encounter*
  - *Patient Condition*
  - FIP execution
    - start in a feasible entry point
    - follow (some) path exiting from the entry point
    - finish either
      - a) in a state that is not a feasible entry point
      - b) in a connector with a temporal range $[\text{min}, \text{max}]$ with $\text{min}>0$. 
Examples I: Partial Knowledge

“Medication is likely to be needed where there is any sustained depressive disorder and when non-pharmacological strategies are not achieving their goals.”

“Useful signs to indicate commencing medication are:
- Presence of biological signs, disturbed sleep, appetite and energy changes
- Diurnal variation in mood
- Agitation or retardation
- Depression with any psychotic features.”

“Admission to hospital can be essential where the depression:
- Is severe enough to impair reasonable daily living function and supports cannot be put in practice
- Has safety issues –suicidal ideas or plans, psychotic signs, severe psychomotor agitation or retardation
- Has not responded to fair treatment”
Examples II: Hypertension

[PROC]: ConfirmElevatedBloodPressure

COMPLETE INITIAL ASSESSMENT

SUSPECTED
otherwise

[REC]: LifeStyleModifications

[PROC]: IncreaseInitialAgent

[PROC]: SubstituyeNewAgent

[PROC]: AddAnotherAgentFromDifferentClass

BP?
otherwise

BP?
AT_GOAL
otherwise

BP?
AT_GOAL
otherwise

HT?
RESISTANT
otherwise

HT?
[SPEC]: UNSPECIFIED

ORDER ADDITIONAL WORK-UP
CONSIDER REFERRAL

HT CONTINUING CARE

SCREENING DIABETES
HEART FAILURE
SECONDARY_CAUSE?
otherwise

SCREENING DIABETES
SECONDARY_CAUSE?
otherwise

BP ≥ 130/80
HEART FAILURE
SCREENING
BP ≥ 140/90
CHRONIC KIDNEY DISEASE
BP ≥ 130/80
DIABETES
SECONDARY_CAUSE?
otherwise

ORDER_ADDITIONAL_WORK-UP
CONSIDER_REFERRAL

HT CONTINUING CARE
Examples III: K4CARE Comprehensive Assessment

[PC]: ReferHCPForCA

[HN]: ReferHCPForCA

[HN]: AssignsEUMembers

[HN]: SendMessageForAppointment

(HCP): ConfirmAppointment

CLINICAL

ASSESSED

[FD]: PhysicalAssessment

[PC]: PhysicalAssessment

PHYSICAL

ASSESSED

[SW]: PerformSocialNeeds

[SW]: PerformSocialNetworkNeeds

SOCIAL

ASSESSED

[HCP]: ProvideNecessaryInformation

[CCP]: ProvideNecessaryInformation

NON-COMPLIANT

otherwise

NON-RELIABLE

[HN]: PerformCaseManagementProperActions
Examples IV: Use of Antidepressant Medication in Elderly

- [PRES]: Antidepressant
  - NO_ANDEPRESSANT
  - RESPONSE?
    - INADEQUATE
      - [ANY]: ReviewDiagnosis
        - [PRES]: Antidepressant
      - NOT_TOLERATED
    - GOOD
      - [ANY]: MaintainEffectiveDose [12 month]
  - NOT_TOLERATED
    - [ANY]: ReviewDiagnosis
      - [PRES]: Antidepressant
  - NO_RESPONSE
    - NO_RESPONSE
    - RESPONSE?
      - NOT_TOLERATED
        - [SPEC]: Psychiatrist
      - CORRECT_DIAGNOSIS
        - NONE_UNDERLYING_MEDICAL_CONDITION
        - NONE_UNTREATED_PSYCHOSOCIAL_STRESSOR
        - CARER_NOT_DEPRESSED
      - [SPEC]: Psychiatrist

otherwise

- INADEQUATE
  - RESPONSE?
    - NO_TOLERATED
      - [ANY]: ReviewDiagnosis
        - [PRES]: Antidepressant
    - GOOD
      - [ANY]: MaintainEffectiveDose [12 month]
  - NOT_TOLERATED
    - [ANY]: ReviewDiagnosis
      - [PRES]: Antidepressant
  - NO_RESPONSE
    - NO_RESPONSE
    - RESPONSE?
      - NOT_TOLERATED
        - [SPEC]: Psychiatrist
      - CORRECT_DIAGNOSIS
        - NONE_UNDERLYING_MEDICAL_CONDITION
        - NONE_UNTREATED_PSYCHOSOCIAL_STRESSOR
        - CARER_NOT_DEPRESSED
      - [SPEC]: Psychiatrist
Examples V: Management of Depression with Cognitive Impairment

[ANY]: InvestigateForMedConditionsOrDelirium

otherwise found?

MEDICAL_CONDITION

DELIRIUM

[PROC]: TreatMedicalCondition
[ANY]: Reassess

[PROC]: CompleteDementiaWorkup
[PROC]: NonPharmacologicalStrategiesForDepressedMood

1 month, 1 month

DEPRESSED MELANCHOLIC

MAJOR_DEPRESSION

SUICIDAL_IDEAS

[SPEC]: Unspecified

[PROC]: HospitalCare

DEPRESSED

CONDITION

otherwise

UNSPECIFIED

[PROC]: ReassessCognitiveStatus

DEPRESSION_RESOLVED

CONDITION

otherwise

CONDITION_STABLED

otherwise

UNSPECIFIED

[PROC]: Antidepressant

UNSPECIFIED
Examples VI: Management of Depression with Dementia

- **MEDICAL_CONDITION**: Investigate&Treat
- **SPEC**: Unspecified
- **PROC**: HospitalCare
- **PROC**: NonPharmacologicalStrategies
- **PROC**: Investigate&Treat
- **PROC**: AddAntidepressant
- **PROC**: HospitalCare
- **PROC**: Refeeding

- **ATYPICAL_DEPRESSION**: SUICIDAL
- **SUICIDAL_IDEAS**: otherwise
- **PAINFUL_CONDITION**: otherwise
- **SUDDEN_DECLINE_IN_FUNCTION**: otherwise
- **DYSPHORIA** (FEELING_TERRIBLE)
- **LOSS_OF_INTEREST**
- **PSYCHOMOTOR_CHANGE**
- **AGRESSION_NOISINESS**
- **REFUSAL_TO_EAT_OR_DRINK**
- **EMOTIONAL_LABILITY**
- **THOUGHTS_OF_DEATH**

- **MELANCHOLIC_FEATURES**: otherwise
- **DEPRESSED**: otherwise

- **CONDITION?**
- **[PROC]**: Investigate&Treat

- **15 (S)HE?**: otherwise
- **SUICIDAL_IDEAS**: otherwise
- **PSYCHOTIC**: otherwise
- **SUICIDAL**: otherwise
- **DEHYDRATED**: otherwise
- **MALNOURISHED**: otherwise

- **[SPEC]**: Unspecified

- **[PROC]**: AddAntidepressant

- **FOUND?**: otherwise

- **[PROC]**: NonPharmacologicalStrategies

- **[1 week, 2]**

- **[2, 3 month]**

- **[PROC]**: HospitalCare
Examples VII: Risk of Assessment and Management of Suicide

[PROC]: EvaluatePrecipitatingFactors
[PROC]: EvaluateProtectiveFactors

otherwise

EFFECTIVE_RISK

IN_RISK

[PROC]: AssignALevelOfRisk

DELIRIUM

[PROC]: RegularReview

LOW

LEVEL?

HIGH

MODERATE

[PROC]: EstablishSafetyNet
[REC]: SetStepsThePatientToFollow

[REC]: SetStepsThePatientToFollow

[PROC]: TransferToHospital
[SPEC]: unspecified [0, 1 day]

HIGH IN_RISK

RISK_ASSESSED

[PROC]: AssignALevelOfRisk

LOW

ELSE

UNSPECIFIED

[PROC]: RegularReview

LOW

LEVEL?

HIGH

[PROC]: EstablishSafetyNet
[REC]: SetStepsThePatientToFollow

[REC]: SetStepsThePatientToFollow

[PROC]: TransferToHospital
[SPEC]: unspecified [0, 1 day]

HIGH IN_RISK

RISK_ASSESSED

[PROC]: AssignALevelOfRisk

LOW

LEVEL?

HIGH

[PROC]: EstablishSafetyNet
[REC]: SetStepsThePatientToFollow

[REC]: SetStepsThePatientToFollow

[PROC]: TransferToHospital
[SPEC]: unspecified [0, 1 day]
Conclusions and Acknowledgements

- K4CARE project
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