Personalized Care Pathways using BPM and AI techniques

Arturo González-Ferrer, PhD
Department of Information Systems

European BPM round table, Nov 5th 2012
Summary

- Formalization of Guideline Knowledge
  - How can BPMN help

- Enabling Clinical Workflow & Therapy Planning
  - Care Pathways
  - How can AI planning/scheduling help?
  - Mix Physician-view, Patient-view, Organizational-view
    - Personalized Care Pathways: Cognocare

- Knowledge-to-Data mapping
  - MobiGuide project
Guideline Knowledge Modeling

Computer-interpretable Guidelines (CIGs) are formalisms developed in the last decade:

- PROforma,
- Asbru,
- GLIF,
- SAGE,
- GLARE,
- EON,…
What BPMN can provide for modeling?

- BPMN able to represent roles/participants
- Temporal Perspective
  - time points,
    - absolute, periodic, relative
  - intervals/durations
    - maximum, minimum, estimated
- temporal constraints
  - As Soon As Possible (ASAP)
  - As Late As Possible (ALAP)
  - Start No Earlier Than (SNET)
  - Finish No Earlier Than (FNET)
  - Start No Later Than (SNLT)
  - Finish No Later Than (FNLT)
- temporal dependencies
  - Start-to-Finish (SF), Start-to-Start (SS)
  - Finish-to-Start (FS), Finish-to-Finish (FF)

Denis Gagné and André Trudel, “Time-BPMN”, First Workshop on BPMN, 2009

“At enactment time, the temporal perspective of the workflow specification leads to the ability to precisely schedule a process and its resources”
Enabling Organizational Workflow & Therapy Planning

Physicians:
- Did the patient take medication?
- Who did what? Who is in charge of what?
- Don't forget the lab test!
- Am I following evidence during treatment?
- How many times did I change dosages/plan?
- Provide recommendations compatible with CPOE

Patients:
- Allow them a personalized care
- Remind them next steps
- Record their recommendations/actions (PHR)
- Personalized CPs adapted to patient's insurance coverage

Managers:
- Are we running out of resources?
- How many nurses do we need next week?
- Do we have a peak of patients at any moment?
- It is safe to reassign resources?
- Are we following evidence GL?
- Show insurance companies that we did according to Clinical Guidelines

“Hardly any of the existing Clinical Decision Support Systems (CDSS) appear to be aimed at supporting extended clinical workflows, management of information and decision-making in plans that unfold over time”

J. Fox et al. Delivering clinical decision support services: there is nothing as practical as a good theory. Journal of Biomedical Informatics, 43(5), 2010
Care Pathways

Aim to model a **timed process** of patient-focused care, by specifying key events, clinical exams and assessments to produce the best prescribed outcomes, **within the limits of the resources available**, for an appropriate episode of care.

Figure extracted from R. Lenz, M. Reichert “IT support for healthcare processes – premises, challenges, perspectives”, Data & Knowledge Engineering 61, 2007
How can HTN AI planning help?

HTN: Hierarchical Task Network

Declarative in nature, but able to also express control flow patterns
Able to express knowledge-based heuristics

It is based in first-order logic, but very useful for domains based on expert knowledge
Integrating technologies

- **CIGs**
  - Model the physician view of care process
  - Their interpretation can provide single-step decision support

- **BPMN**
  - Model the organization view of care process
  - It can represent knowledge about roles, resources that are not included in CIG

- **Artificial Intelligence P&S**
  - Can use the knowledge provided by CIGs and BPM models
  - Provide a treatment plan considering physician, patient, and organizational views
  - Can model heuristics to drive the search of the goal plan
AI Planning approaches

- **Fully deliberative approach**
  - A plan or process is designed hoping that everything is going to happen as expected and everything is fully predictable

- **Fully reactive approach**
  - The outcome of some tasks may not be predicted

- **Building processes with conditional branches**
  - The branch to be executed depends on the satisfaction of certain conditions (e.g. BPM)

- **Continual planning**
  - Dynamically building a simple process, perhaps the most likely to be successful until the end or until an intermediate milestone, try to execute it, discard it when it fails, and quickly re-build a new one

---

Dwight D. Eisenhower

*In preparing for battle I have always found that plans are useless, but planning is indispensable*
Knowledge Engineering: BPM/CIG to HTN P&S


- JABBAH: [http://sites.google.com/site/bpm2hth/](http://sites.google.com/site/bpm2hth/)

Cognocare is based on IActive’s award-winning technology


Award-winning Artificial Intelligence engine


International Conference on Planning & Scheduling. Award for Best Application. ICAPS 2006. United Kingdom.
The Cancer Problem

- High incidence, prevalence and cost
- High complexity
- Evidence-based medicine is not personalized
- Constant change of patient conditions

BPM round table, Eindhoven, Nov 5th.
**What do physicians need?**

- To design personalized treatments efficiently
- To conform to evidence-based medicine
- To keep up with the latest practice guidelines
- To react to patient’s changing conditions

**At the point of care!**

BPM round table, Eindhoven, Nov 5th,
Alerts about scheduled lab tests
Detailed explanations about dosages
Physicians may modify the details of the treatment
Next scheduled test
Log of every decision made
Tentative forecast of the treatment (subject to lab tests)
Estimation of Resources

Difficulties
- Integration with EMRs
- Integration of the provided output with CPOEs
Knowledge-Data: The good & evil simile

to enable this bridge we need someone smart
Knowledge Engineering

Turning the process of constructing Knowledge Based Systems from an Art into an Engineering Discipline, using better methodological approaches

Studer et. al, Knowledge Engineering: Principles and Methods, 1998
Knowledge-Data Mapping

Clinical concept (pregnancy) is clear to doctors, and to all of us, data representation of this concept can be very different.

How to evaluate if a patient is pregnant?

BPM round table, Eindhoven, Nov 5th,
The MobiGuide project develops an intelligent system for patients with chronic illnesses, such as cardiac arrhythmias, diabetes, and high blood pressure. The patients wear sensors that can monitor bio-signals (e.g., heart rate, blood pressure); the signals are transmitted to their Smartphone. The MobiGuide decision-support tools analyse the data, alert the patient about actions that should be taken, ask the patient questions (in the case that additional information is needed) and make recommendations regarding lifestyle changes or contacting care providers. All recommendations regarding therapy are transmitted to the patients’ care providers.
There is no worse death than the end of hope

Thanks! contact me at: arturogf@gmail.com