Decision Support for Managing Pediatric Asthma Exacerbations: Designing a CDSS Using the MAS Paradigm

Szymon Wilk¹, Ken Farion², Stan Matwin³, Wojtek Michalowski¹, Dympna O'Sullivan¹

MET Research Group, University of Ottawa
¹ Telfer School of Management
² Departments of Pediatrics and Emergency Medicine
³ School of Information Technology and Engineering
Outline

- Integrated decision support
- Multi-agent systems for clinical decision support
- O-MaSE methodology
- Management of pediatric asthma
- MET-A³-Support and its O-MaSE process
- Conclusions
Scenario: Managing Patient in ED

1. ADT sends registration record to the CDSS.
2. The physician uses the CDSS to records data and asks for diagnostic support.
3. The CDSS provides diagnostic suggestion.
4. The physician orders PEFR test and the CDSS passes this request to CPOE.
5. Subsequent management process follows.
6. Upon prescription of a treatment, the CDSS consults an embedded CPG.
7. The physician requests the evidence and the CDSS retrieves it from the Cochrane Library.
8. Patient management is continued.
Integrated Decision Support

- Goal: provision of decision support at the point of care integrating clinical data with clinical knowledge

- Intensive, but disjoint research on:
  - Electronic health record (EHR)
  - Clinical decision support systems (CDSS)
  - Computerized clinical practice guidelines (CPG)
  - Repositories of clinical evidence
Problems and Challenges

- Information and knowledge are distributed.
- Provision of integrated support requires dealing with several decision problems.
- Solving some problems may require advanced models (OR, AI).
- Supporting patient management may require using "services" provided by a hospital.
- All information and decisions have to be shared for continuity and coordination of care.
Solution for CDSS Architecture: Multi-agent System

- A multi-agent system (MAS) is a collection of autonomous entities (agents)
- Agents exchange and share information to achieve a common (complex) goal
- Agents react in a proactive and intelligent way to changes in clinical decision situation
- Blurred boundary between multi-agent systems and service-oriented systems
Organization-based Multi-agent System Engineering (O-MaSE)

- Structured engineering methodology for creating MAS
- Abstraction of object-oriented paradigm (agents are specialized objects)
- Provides a set of tasks and guidelines specifying how to combine tasks together depending on the requirements for the specific MAS
- Assumes a MAS is an organization of agents that play specific roles in order to achieve a common goal
Management of Pediatric Asthma Exacerbations in the ED

- Asthma exacerbation is one of the most common medical reasons for children to be brought to the ED.
- At CHEO, in 2003, there were 2385 patient visits for asthma, with a mean length of stay of 288 minutes (47% of visits longer than 4 hours).
- Asthma management at CHEO includes a clinical pathway that was first introduced in 1999.
Management of Pediatric Asthma Exacerbations in the ED
MET-A$^3$Support-Asthma (MET-A$^3$-AE)

- Provides integrated decision support for management of pediatric asthma at the point of care
- Used by physicians and nurses in the ED
- Gives the users full control over the agents – users define their goals and activate specific agents
Goal Model

0. Provide integrated decision support

1. Manage and synchronize patient data
   1.1 Manage and synchronize patient data
   1.1.2 Manage patient data
   2. Manage and support encounters
      2.1 Manage encounters
         uid : UserID
      2.2 Support encounters
         pr : PatientRecord

3. Provide suggestions and evidence
   3.1 Suggest evaluation
      pr : PatientRecord
   3.2 Suggest treatment
      pr : PatientRecord

4. Manage security and privacy
   4.1 Manage privacy
      uid : UserID
      pr : PatientRecord
   4.2 Manage security
      uid : UserID
      p : Password

5. Provide evidence
   pr : PatientRecord
   t : Treatment
Domain Model/Ontology
Role/Agent Class Model

- **Role**: EvaluationSuggester
  - achieves Suggest evaluation

- **Role**: TreatmentSuggester
  - achieves Suggest treatment

- **Role**: EvidenceProvider
  - achieves Provide evidence

- **Role**: EncounterSupporter
  - achieves Support encounter

- **Role**: PrivacyManager
  - achieves Manage privacy

- **Role**: DataManager
  - achieves Manage patient data

- **Role**: SecurityManager
  - achieves Manage security

- **Role**: HISSynchronizer
  - achieves Synchronize patient data

- **Role**: HIS
  - sends HISEvent
  - sends MET3Event

- **Role**: RequestData
  - updates DataUpdatedByUser
  - updates DataUpdatedByHIS

- **Role**: RequestEvidence

- **Role**: RequestTreatment

- **Role**: RequestEvaluation

- **Role**: ConductEncounter

- **Role**: ManageEncounter

- **Role**: RequestSystemAccess
Protocol Models

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Plan Models
Complex model was developed from prospective data using data mining techniques enhanced with:
- Secondary clinical knowledge
- Contextual normalization

Model is customized for local settings, readable and interpretable.
Evidence Provider Agent

- Complex ontological model of concepts was created for indexing entries in Systematic Reviews section of the Cochrane Library
- Focused retrieval methodology was developed to enable patient-specific queries
Implementation Issues

- MET-A³Support will be designed for multiple computing platforms (tablets, desktops, handhelds)
- MET-A³Support should work in weak connectivity conditions (inaccessible WiFi, longer battery life)
- MET-A³Support should conform to PHIPA regulations
Conclusions

- MET-A³Support is suitable for any integrated CDSS application
- Structured engineering methodology (like O-MaSE) is required for successful implementation
- Integrated support asks for complex decision and information retrieval models
- MET-A³Support enhances use of the CPG at the point of care
MET Research Group @ uOttawa

http://www.mobiledss.uottawa.ca