Towards Systematic Model-Based Development of Patient Management Systems

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Outline

• Brief project overview
  – Long Term Goal
  – Sepsis and the ICU

• Early Warning: The Listening Application
  – Preliminary Data

• Improving Compliance: Process Management
  – A Prototype and Plan for Improvement

• Clinical Trial and Implementation
• Provide electronic support for complex decision making in health care which improves quality of care. Make tools that analyze patients’ electronic records and...
  
  – Assist in diagnosis of multiple diseases.
  
  – Improve adherence to evidence-based guidelines in disease management.
Sepsis and the ICU...

**Sepsis**
- Common, Deadly
- Affects inpatients
- Difficult to diagnose
- Early treatment is superior
- Effective treatment requires an array of multi-step interventions.

**The ICU**
- Instability in multiple organ systems
- Information rich
- Decision rich
- Rapidly growing use of protocols
Early Warning: The Listening Application

- An application positioned within our system to monitor patient data (flow sheet data, laboratory data, etc.).
- Programmed to generate alerts to physicians (via the dashboard and pager system) when certain criteria are met.
- Rules engine able to “filter” alerts and ensure that only new or pertinent alerts are generated.
- May be applied to many disease processes.
Early Warning: The Listening Application

- Applied to sepsis in our pilot project.
- Monitors for modified SIRS criteria.
- When criteria are met,
  - Rules engine ensures that information is new and pertinent.
- Has been deployed in the MICU and SICU.
The Listening Application

Preliminary Data from the MICU (80 pts.):

• 100% sensitive for sepsis
• ~60% specific for sepsis
• Did not alter behaviors, including time to 1st antibiotics, time to change of antibiotics, ICU time, vent time, shock time, mortality.
  – This is not unexpected within the MICU, where provider:patient ratio is low, suspicion for sepsis is high.
  – 10% of patients had not received antibiotics at the time of the alert...
1. Identify patients based on modified SIRS criteria
2. Prompt clinical teams
3. Provide real-time process management recommendations based on live patient data
4. Process confirmed orders
Creation and Deployment of Treatment Models

CPOE (WizOrder) → Sepsis Management GUI → Patient Management Dashboard → Surveillance Tool

Physician

EMR DB Service

Patient
Creation and Deployment of Treatment Models

- **Physician**
- **Protocol Models**
  - GME
- **Derived Protocol Representation**
  - XML

**Sepsis Management GUI**

**Execution Engine**
Design of the Clinical Process Modeling Language
1. General medical ontology
Medical Knowledge
1. General medical ontology
2. HCO-specific ontology

CPML

RootFolderElements
<<FCO>>

MedicalLibrary
<<ModelProxy>>

Orderables
<<ModelProxy>>

Protocols
<<ModelProxy>>
CPML: HCO-specific Ontology
Medical Knowledge
1. General medical ontology
2. HCO-specific ontology
3. Patient management protocols
   - Conditions
   - Constraints and Well-formedness Rules
   - Execution Flow
   - Composition

CPML
- RootFolderElements
  - MedicalLibrary
  - Orderables
  - Protocols
CPML: Patient management protocol

ComplexFlowElements <<FCO>>
- Priority : field
- InfoSourceLink : field
- InfoText : field
- UIRepresentation : field

Notification <<Model>>
- InitiallyActive : bool
- EntryCondition : field
- OffCondition : field
- Optional : bool
- Address : field

Process <<Model>>
- InitiallyActive : bool
- EntryCondition : field
- SkipCondition : field
- OffCondition : field
- Optional : bool
- UIHeadline : field
- Abstract : bool

Activity <<FCO>>

LabBundleRef <<Reference>>
- Vocabulary : field
- ConceptID : field

MedBundleRef <<Reference>>
- Vocabulary : field
- ConceptID : field

ProcedureRef <<Reference>>
- Vocabulary : field
- ConceptID : field

ProtocolRef <<Reference>>
- InitiallyActive : bool
- EntryCondition : field
- SkipCondition : field
- OffCondition : field
- Optional : bool
- GoalCondition : field

Protocol <<ModelProxy>>
- UIHeadline : field

Protocols <<Model>>
- 0..* InterProcessPrimitive <<FCOProxy>>

Sztipanovits: 20
Medical Knowledge

1. General medical ontology
2. HCO-specific ontology
3. Patient management protocols
   - Conditions
   - Constraints and Well-formedness Rules
   - Execution Flow
   - Composition

CPML

Inside the Modeling Environment 6/9
Inside the Modeling Environment 7/9
Inside the Modeling Environment 8/9

Metamodel Editor
- CPML Metamodel

Metamodel Translator

Model Editor
- Patient Management Models

Inside the Modeling Environment 8/9
Inside the Modeling Environment 9/9

Metamodel Editor
- CPML Metamodel

Metamodel Translator

Model Editor
- Patient Management Models

Diagnostics
- Blood Culture
- CBC & diff. & Platelets
- Sputum Culture
- Blood Type & Screen
- Lactate
- Urinalysis

Diagnostics orderables
- BMP
- Blood Culture
- Blood Type & Screen
- CBC & diff. & Platelets
- Lactate
- PT, PTT, INR
- Sputum Culture
- Urinalysis
- Urine Culture

Therapeutics
- Septic Shock Rx
- Early Goal-Directed Therapy
- Prophylaxis

Sztipanovits: 24
Content

1. Principles
2. Protocol modeling language for a sepsis management
3. Engine for Model-integrated patient management and decision support systems
Introduction to the CPM GUI and Execution Engine

1. The Layout of the CPM User Interface
2. The Anatomy of the CPM Runtime (Execution Engine)
3. Execution Semantic of the Runtime (Execution Engine)
Provides guideline based decision support in the context of the patient

1. Patient View – shows patient health status

2. Protocol View – shows status of the personalized protocol

3. Patient Alerts - helps situation awareness

4. Listener and Orderables - Integration into Clinical workflow
Anatomy of the CPM Runtime

Provides guideline based decision support in the context of the patient

1. Patient View – shows patient health status

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Anatomy of the CPM Runtime

Protocol Visualization

Protocol and Orders Mediator

Decision Support
(individualized protocol execution)

Protocol Executor

Configuration Information Path

Chart Visualization

Protocol Models Visualization

Chart UI

Protocol & Orders UI

Persistency DB

Orders to HEO

CPOE Interface

EMR Interface

HL7 Patient Data

JDBC Hibernate

CPML Translator

File IO

Runtime Configuration

Protocol Executor

Diagram showing the integration of various components such as protocol visualization, protocol and orders mediator, decision support, protocol executor, configuration information path, chart visualization, protocol models visualization, chart UI, protocol & orders UI, persistency DB, CPOE interface, EMR interface, HL7 patient data, JDBC Hibernate, CPML translator, file IO, and runtime configuration.
Protocol Engine Semantics

### Entry Criteria

- Explicit or Parent initiated activation
- Order placed for an Orderable
- Administration of the Orderable started
- Any children in Ordered or Running state

### Skip/Off Criteria met

- Administration of the Orderable or all children finished

### Decision Support

- (individualized protocol execution)

### Protocol Executor
Example:
Fluid Challenge in Septic Shock

Septic Shock and Fluid Challenge
Example:
Fluid Challenge in Septic Shock

Fluid Challenge process: Entry-criteria MAP < 60

Normal Saline orderable:
Thank You

Questions?