The EON Guideline Modeling System

Samson W. Tu

Stanford Medical Informatics
Stanford University School of Medicine
Stanford, CA
Overview

- Introduction to EON architecture for creating DSS for guideline-based care
- Components of EON guideline modeling system
  - Concept model
  - Patient data model
  - Expression language
  - Guideline model
- Questions
Genealogy of EON Guideline Model

- Successive projects to develop guideline-based decision-support
EON Research Problems

- How to model clinical guidelines and protocols to provide patient-specific DS?
- How to create a knowledge-engineering environment to facilitate encoding of guidelines and protocols?
- How to represent, reason with, and visualize time-oriented patient data?
- How to present and explain DS recommendations and conclusions?
EON 2.0
A Component-Based Architecture

Clients
- Data-Display Client
- Eligibility Client
- Advisory Client
- Explanation

Servers
- Temporal Mediator
- Eligibility Server
- Guideline Advisory Server
- Protégé

Patient Database
Guideline Knowledge Base
EON Modeling Approach

- Modeling, not programming
  - Encoding guidelines is a modeling process requiring training
  - Guideline encoders tell the system appropriate domain knowledge
- Allow alternative methods for performing a task
  - Goal: plug in only those knowledge structures needed to solve a particular problem
- Ease of use (by clinical collaborator) a design criterion
  - But sometimes making something easy makes other things hard
Overview

- Introduction to EON architecture for creating DSS for guideline-based care
- Components of EON guideline modeling system
  - Concept model
  - Patient data model
  - Expression language
  - Guideline model
- Questions
Guideline Modeling as Creation of a Set of Interacting Models

Temporal-Abstraction Model \rightarrow Guideline Model \rightarrow \ldots

Guideline Model \rightarrow Expression Languages \rightarrow 3

Expression Languages \rightarrow uses \rightarrow Guideline Model

Guideline Model \rightarrow depends on \rightarrow Patient Data Model (VMR)

Patient Data Model (VMR) \rightarrow 2

Medical Concept Model \rightarrow 1
1. EON Guideline Component: Medical Concept Model

- Defines
  - Taxonomic hierarchy of concepts (e.g., ACE inhibitor) used in guidelines
  - Relationships among concepts (e.g., indications for ACE inhibitor)

- Supplies
  - Controlled terminology for guideline encoding
Why Not Use Standard Vocabulary Directly?

- Need for strict is-a classification hierarchy
- Need to index medical and guideline knowledge
- Need for definition of guideline-specific concepts and axis of classification
  - DM not taking ARB:
    - Presence of DM and absence of prescription for ARB
- Need to organize mappings to host-system data dictionary
2. EON Guideline Component: Patient Data Model

- Simplified model of patient information
  - Focus on clinical and demographic information needed for clinical decision making
  - Flat hierarchy for easier mappings to relational database
  - Data are time-stamped, interval-based, or static
Use of Patient Data Model

- Patient data model defines the types of assertions that can be made about patient situation
- Patient data model allows alternative expression languages
  - Template-based
  - Temporal
  - Logic-based
3. EON Guideline Component: Expression Language

- Template-Based Criterion Language
  - Fill-in-blank templates to encode relatively simple expressions

Absence of potassium lab result within the last 7 days
3. EON Guideline Component: Expression Language

**Temporal Query and Criterion Language**

*an episode of uncontrolled blood pressure that overlaps with use of lisinopril and starts within two weeks of initiating lisinopril*

```sql
TEMPORAL SELECT domain_name
VALID INTERSECT(Condition, Medication)
FROM Condition, Medication
WHERE domain_name = "UNCONTROLLED_BP" AND
drug_name = "lisinopril"
WHEN start(Condition) AFTER start(Medication) AND
start(Condition) BEFORE
    (start(Medication) + weeks(2))
```
3. EON Guideline Component:
Expression Language

- Logic-Based Query and Criterion Language

- No current medication is contraindicated

(defrange ?current_med :FRAME Medication)
(defrange ?med_class :FRAME Drug_Class)

... (not (exists ?current_med
 (exists ?med_class
 (and (subclass-of
 (drug_name ?current_med) ?med_class)
 (exists ?contraindication
 (and (Absolute_Contraindications
 ?med_class ?contraindication)
 (exists ?problem
 (subclass-of
 (domain_term ?problem)
 ?contraindication))))))))
Why Three Expression Languages?

- Knowledge-acquisition requirement
  - Clinicians feel comfortable encoding template criteria with little training!

- Expressiveness requirement
  - Need to detect complex temporal patterns
  - Need to write general expressions that range over a set of objects (forall, exists)

- Component-orientation
  - Temporal query/abstraction engine made a component usable by various applications

- Synergy with sister project
  - Use Protégé constraint language as expression language
4. EON Guideline Component: Guideline Model

- Task-oriented view
  - Must contain concepts and relations for encoding guideline knowledge needed to perform specific task
    - Patient-specific decision support

- Domain-oriented view
  - Must use domain-oriented abstractions sensible to clinical collaborators
    - e.g., model indications and contraindications as relations among drugs and medical conditions
Task-Based Approach to Defining Guideline DS Functionalities
4.1 EON Guideline Model: Setting Goals

*For diabetic patients, the target blood pressure is 135/80 mm Hg*

- Each guideline or subguideline has an AND/OR goal tree
  - OR subgoals modeled as a set of conditional goals
  - Conditional goal
    - Selection criteria: "presence of diabetes"
    - Goal criteria: "systolic BP < 130 mm Hg and diastolic BP < 80 mm/Hg"

- Criteria language allows query of whether goals are satisfied
- Satisfaction of goal as reason for making choice
4.2 EON Guideline Model: Interpreting Data

- Terminological abstraction: use is-a hierarchy of concept model
- Non-temporal abstraction: use concept-definition capability
  
  "DM not ARB" := presence of DM and absence of angiotensin 2 receptor blocker prescription

- Temporal abstraction: use Resume/RASTA

Does there exists grade 2 granulocytopenia that lasts for more than 2 weeks?
4.3 EON Guideline Model: Sequencing Decisions and Actions

- A process model that organizes scenarios, decisions and actions over time
  - Scenario: landmark patient states where
    - real patient situation can be synchronized with process state
    - context-specific actions are specified
    - decisions need to be made
  - Flow-of-control: sequencing, repetition and concurrency of actions and decisions
  - Nesting: Hierarchical decomposition of processes
- Represented as diagrammatical flowchart
Example of Guideline Management Process

Concurrent actions

Alternative choices

Patient scenario

Action step

If-then-else decision

Subguideline
4.4 EON Guideline Model: Action Specification

- Specification of acts to be performed
  - Actions that change states of activities
    - start, stop, change attributes (abort, delay, suspend, resume)
  - System and medical actions
    - e.g. send a message vs. order a test
  - Temporal specification
    - e.g. return appointment in 3 months
  - Use of standard medical terminology
    - e.g. ordering a specific lab test
4.5 EON Guideline Model: Action Refinement

Give ACEI

Preferred drug

Give lisinopril

Give dose
4.6 EON Guideline Model: Making Decisions

- Extensible decision architecture
- Decision step
  - Choice based on conditional rule
  - Choice based on pros-and-cons argumentation
  - ...

![Diagram showing decision process](image)
Overview

- Introduction to EON architecture for creating DSS for guideline-based care
- Components of EON guideline modeling system
  - Concept model
  - Patient data model
  - Expression language
  - Guideline model

Questions
Questions

- How to represent and use goals?
- Are there different “process” models?
  - Is scenario necessary?
- Where do you draw the line
  - between general medical knowledge and guideline knowledge?
  - between terminological ontology and knowledge base?
- Are HL7 Act classes sufficient as the basis for action specification?
- Why not model action refinement as subguidelines?
- Should expression language be declarative?
- How to use standard vocabularies?