A Decompositional Approach to Executing Quality Data Model Algorithms on the I2B2 Platform

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Disclosure

• William Thompson is co-founder of Textractor Technologies LLC
Learning Objectives

• Recognize the challenges and advantages to using i2b2 as the target execution platform for QDM-based algorithms

• Understand how QDM algorithms can be decomposed into workflows of unit i2b2 messages, then orchestrated into workflows and executed on the KNIME data analytics platform
Introduction – Quality Data Models (QDM)

• Used to express patient, clinical, and community characteristics as well as the basic logic required to express quality measure criteria.

• Can be used to represent electronic health records (EHR)-driven phenotype definitions. (Thompson et al., AMIA Annu Symp Proc. 2012:911-20)

• Formats: XML (aka. HQMF, transformable to html), json.
**Example:**

(CMS 30) Statin prescription at discharge

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Cite: ProjectCypress.org
Phenotype Execution Modeling Architecture (PhEMA) Project

Mo et al. 2015
Desiderata for ...
JAMIA, 22(6):1220-30
Informatics for Integrating Biology and the Bedside (i2b2)
Query Messaging of i2b2

<query_definition>
  <query_name>Diabetes mellitus</query_name>
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    <panel_accuracy_scale>100</panel_accuracy_scale>
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    <panel_timing>ANY</panel_timing>
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      <item_name>Diabetes mellitus</item_name>
      <item_key>/i2b2_DIAG/i2b2/Diagnoses\Endocrine disorders (240-259)\Other endocrine gland diseases (250-)</item_key>
      <tooltip>Diagnoses \ Endocrine disorders \ Other endocrine gland diseases \ Diabetes mellitus</tooltip>
      <class>ENC</class>
      <item_icon>FA</item_icon>
      <item_is_synonym>false</item_is_synonym>
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    <level>5</level>
    <item_name>GLUCOSE, PLASMA (LOINC:2345-7)</item_name>
    <item_key>/i2b2_LABS/i2b2/LabTests\LAB\(LLB16\) Chemistry\(LLB22\) Lytes/Renal/Glucose\GLU\LOINC:2345-7\</item_key>
    <tooltip>LabTests \ Chemistry \ Lytes/Renal/Glucose \ Glucose (Group:GLU) \ GLUCOSE, PLASMA (LOINC:234)</tooltip>
    <class>ENC</class>
    <item_icon>LA</item_icon>
    <item_is_synonym>false</item_is_synonym>
    <constrain_by_value>
      <value_type>NUMBER</value_type>
      <value_unit_of_measure>mg/dl</value_unit_of_measure>
      <value_operator>GT</value_operator>
      <value_constraint>200</value_constraint>
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  </item>
</query_definition>
Introduction: Computing Health Quality Measures Using Informatics for i2b2 (Klann 2013)

• J Med Internet Res: 15: e75

• Implemented in Java and XSLT running within i2b2 Jboss

• “Also, HQMF allows unrealistic query constructions.”
KNIME Analytics Platform
KNIME to represent QDM (CMS30)

VSAC: Value Set Authority Center

AMIA Jt Summits Transl Sci Proc.
2015: 127–131
Design:
Decomposition of Quality Data Model

• QDM Operator Modules
  • Data elements
  • Logical Operators (all-true, at-least-one-true, all-false; AND, OR, NOT)
  • Temporal Operator (Event A Starts <= 120 d Before Start of Event B)

• Implementation
  • Each module is represented as an i2b2 query message

• Data flow between modules: via result_type_id
Query result fragment of an i2b2 response message

<query_result_instance>
<result_instance_id>28</result_instance_id>
<query_instance_id>15</query_instance_id>
<description>Patient Set for "Diabetes mellitus@14:57:11"</description>
<query_result_type>
<result_type_id>1</result_type_id>
<name>PATIENTSET</name>
<display_type>LIST</display_type>
<visual_attribute_type>LA</visual_attribute_type>
<description>Patient set</description>
</query_result_type>
<set_size>11</set_size>
<obfuscate_method />
<start_date>2016-02-18T01:57:28.834-05:00</start_date>
<end_date>2016-02-18T01:57:29.734-05:00</end_date>
<message />
<query_status_type />
</query_result_instance>
Design – i2b2 messages

• Template of i2b2 Messages: from i2b2 VM web client, from a similar standard one-step operation

• Parameter List
  (temporal: “encounter set #128” <= 120 d Starts before Start of “set #125”):
    • Span_operator: LESSEQUAL; span_value: 120; units: DAY
    • Temporal_operator: LESS; join_column(left): STARTDATE; join_column(right): STARTDATE
    • Item_key(left): patient_set_enc_id: 128
    • Item_key(right): patient_set_enc_id: 125

• Xpath Maps: temporal operator:
  /ns6:request/message_body/ns4:request/query_definition/subquery_constraint/operator

• RESTful communications with i2b2 servers for query requests
Authoring i2b2 messages
Implementation of a QDM Operator Module
Test Case: eMERGE type 2 diabetes algorithm

Population Criteria

- Initial Population =
  - AND NOT: "Diagnosis, Active: Type 1 Diabetes Mellitus, Type One Diabetes Mellitus, T1DM"
  - AND:
    - OR:
      - AND:
        - OR: "Laboratory Test, Performed: Glucose blood serum plasma (result > 200 mg/dL)"
        - OR: "Laboratory Test, Performed: Hemoglobin blood serum plasma (result >= 6.5 %)"
      - AND: "Medication, Active: T2DM Medications (Type 2 Diabetes Mellitus)"
      - AND NOT: "Medication, Active: T1DM Medications. (Type 1 Diabetes Mellitus)"
    - OR:
      - AND: "Diagnosis, Active: Type 2 Diabetes Mellitus, Type Two Diabetes Mellitus"
      - AND: "Medication, Active: T2DM Medications (Type 2 Diabetes Mellitus)" starts before start of "Medication, Active: T1DM Medications. (Type 1 Diabetes Mellitus)"
Test Implementation in KNIME
Test Result (from i2b2 built-in test data)

<table>
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<tr>
<th>patient_id</th>
<th>T1DM Dx</th>
<th>T2DM Dx</th>
<th>Gluc &gt; 200 mg/dl</th>
<th>A1C ≥ 6.5 %</th>
<th>T1DM Med</th>
<th>T2DM Med</th>
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Discussion

• As a prototype (update: alpha version of HQMF -> i2b2 translator is finished)

• Implemented on KNIME, but this design can be agnostic to platforms

• Benefit of i2b2: modular design, open messaging system, reusable result sets

• Value sets are difficult to use in i2b2 (update: implemented)

• Limitation: not yet tested for real-world performance
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