



Modeling Guidelines for Integration into Clinical Workflow

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Apelon, Inc., IDX Systems Corporation, Intermountain Health Care, Mayo Clinic, University of Nebraska Medical Center, Stanford Medical Informatics

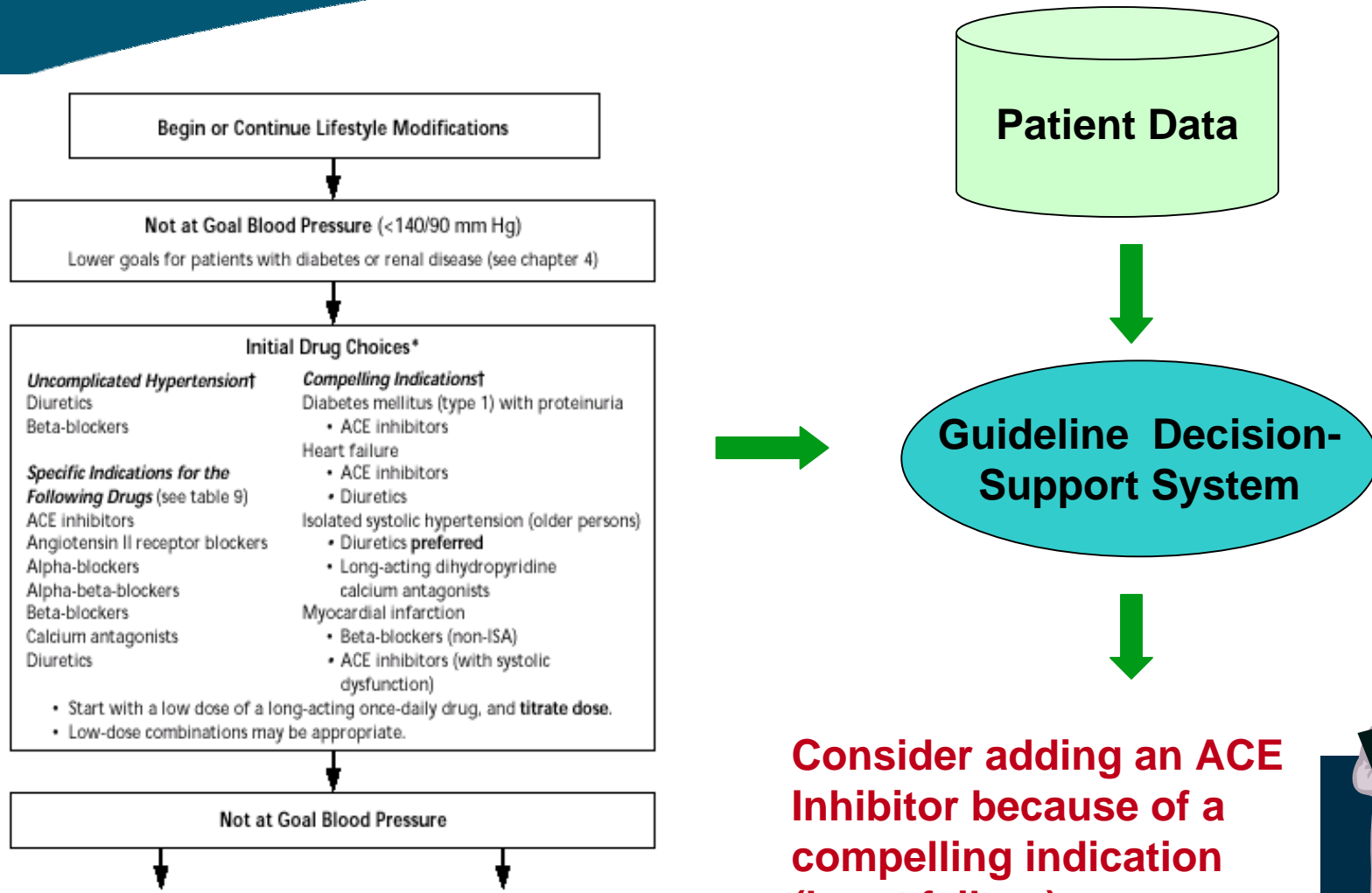
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SAGE: Standards-Based Active Guideline Environment

- 3-year US NIST Advanced Technology Program grant
- IDX leads R&D consortium that includes as partners:
 - Apelon, Inc.
 - Intermountain Healthcare (IHC)
 - Mayo Clinic
 - University of Nebraska Medical Center (UNMC)
 - Stanford Medical Informatics (SMI)
- Ultimate goal: An **infrastructure** that will allow execution of **standards-based** clinical practice guidelines across **heterogeneous clinical information systems** (CIS)
- Focus is on the goal of **deployment** of guideline knowledge **within the workflow** of clinical information systems

Decision Support For Guideline Based Care



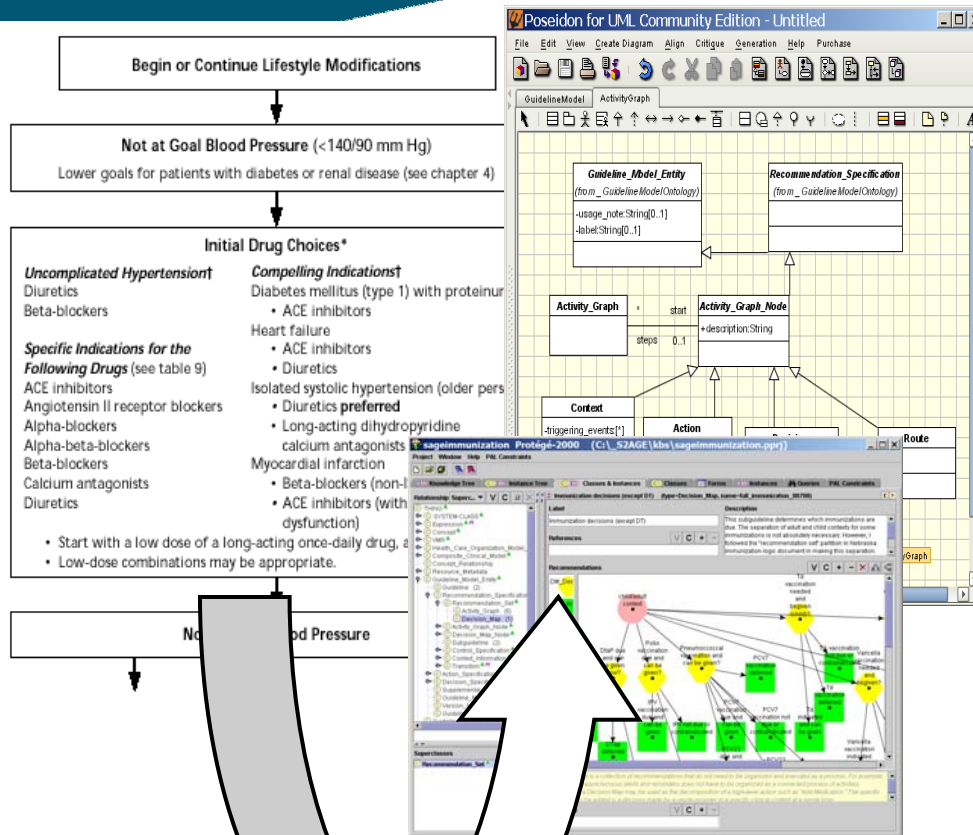
Consider adding an ACE Inhibitor because of a compelling indication (heart failure)



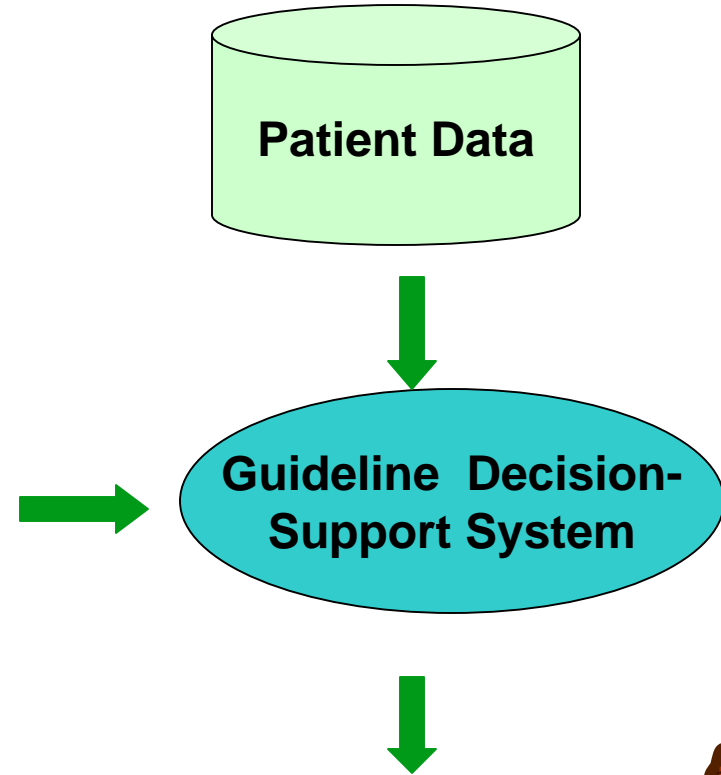
“Clinical decision support must be integrated with workflow”

- Alert and reminders “must appear either at the **appropriate time** for consideration and action, or in a manner in which the **user can determine if and when to evaluate and respond to it**” (Krall, AMIA 2002)
- “...most valuable workflow support would come from **automated documentation** of interval assessment...Examination of **action boxes** suggests additional areas for workflow support...” (Shiffman, SCAMC 1994)
- “...a **workflow management system** (WFMS) could be a suitable tool to **fully implement a GL** and to control both its execution and outcome” (Quaglini, AIM 2000)

Problem: How to Create Computer-Interpretable Guideline Knowledge Base so that the DSS Supports Clinical Workflow



Guideline Modeling Process



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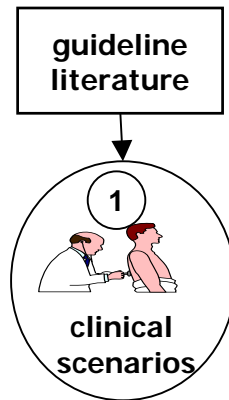


SAGE Approach: Deployment-driven Guideline Modeling

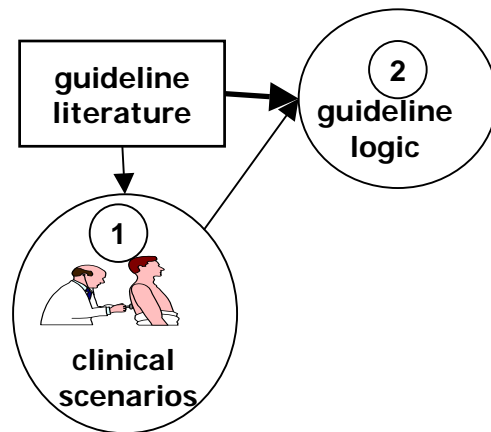
SAGE Approach: Deployment-driven Guideline Modeling

guideline
literature

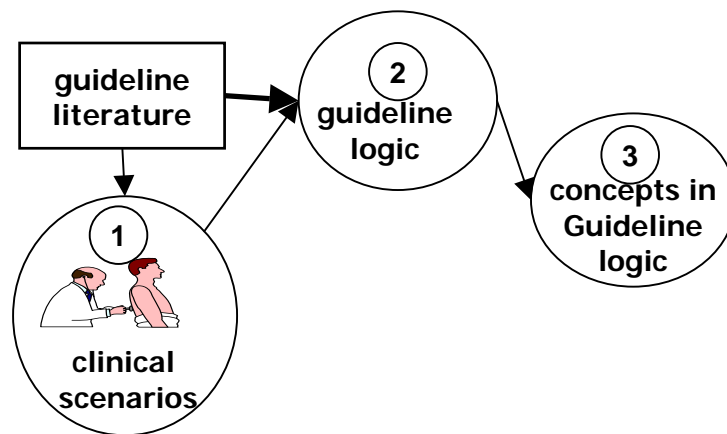
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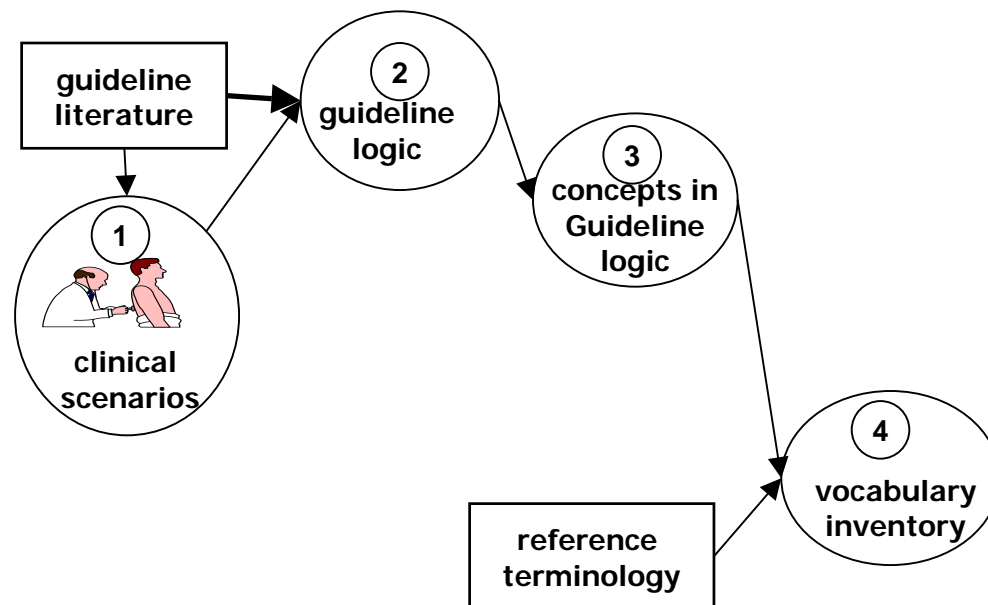
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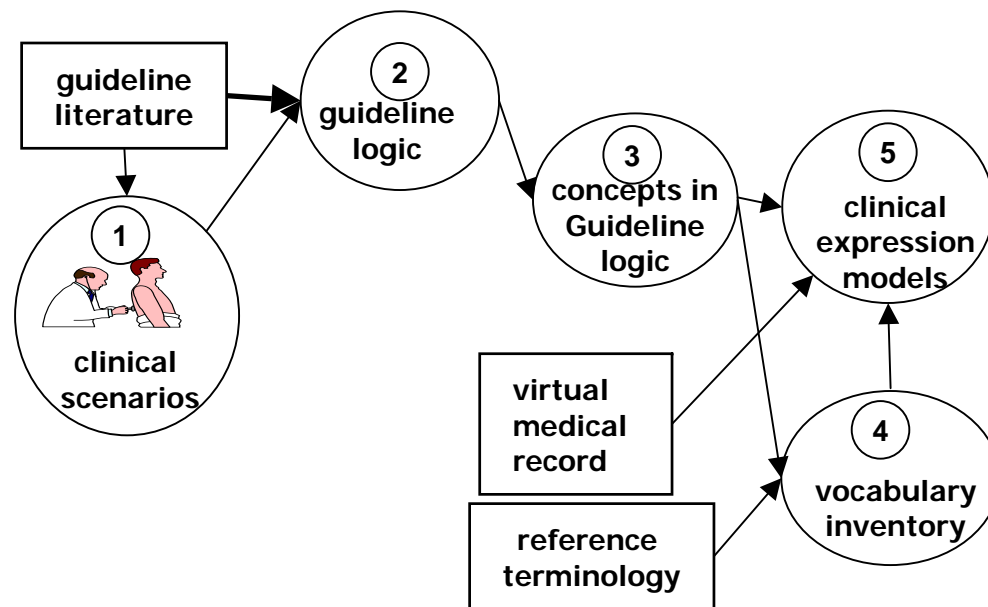
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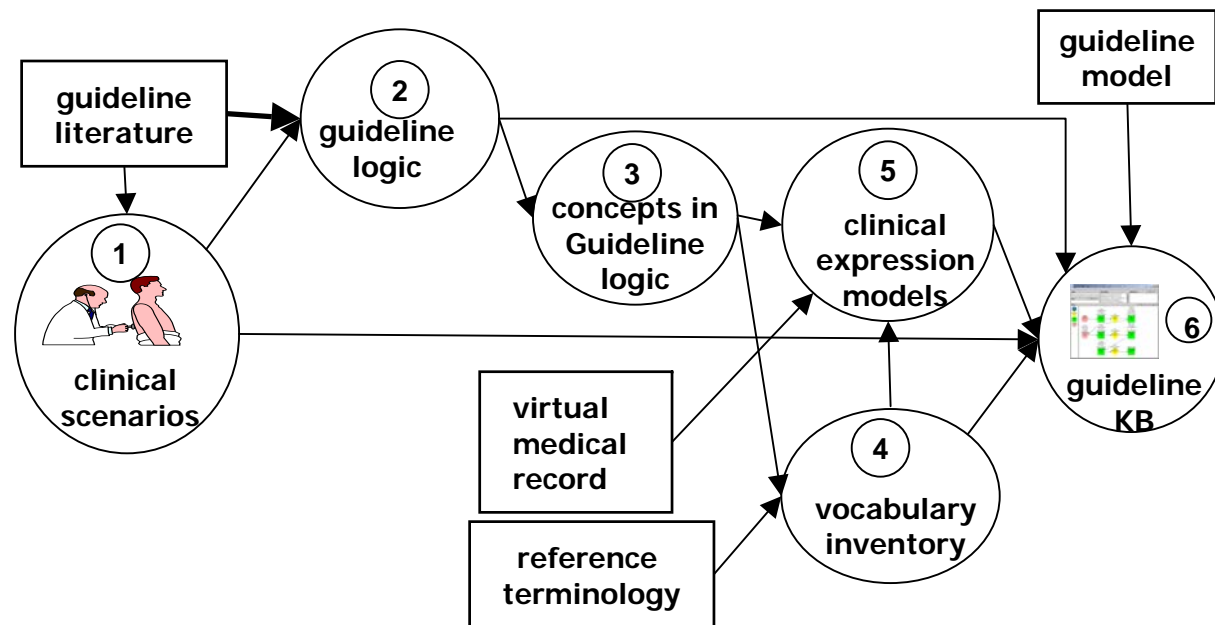
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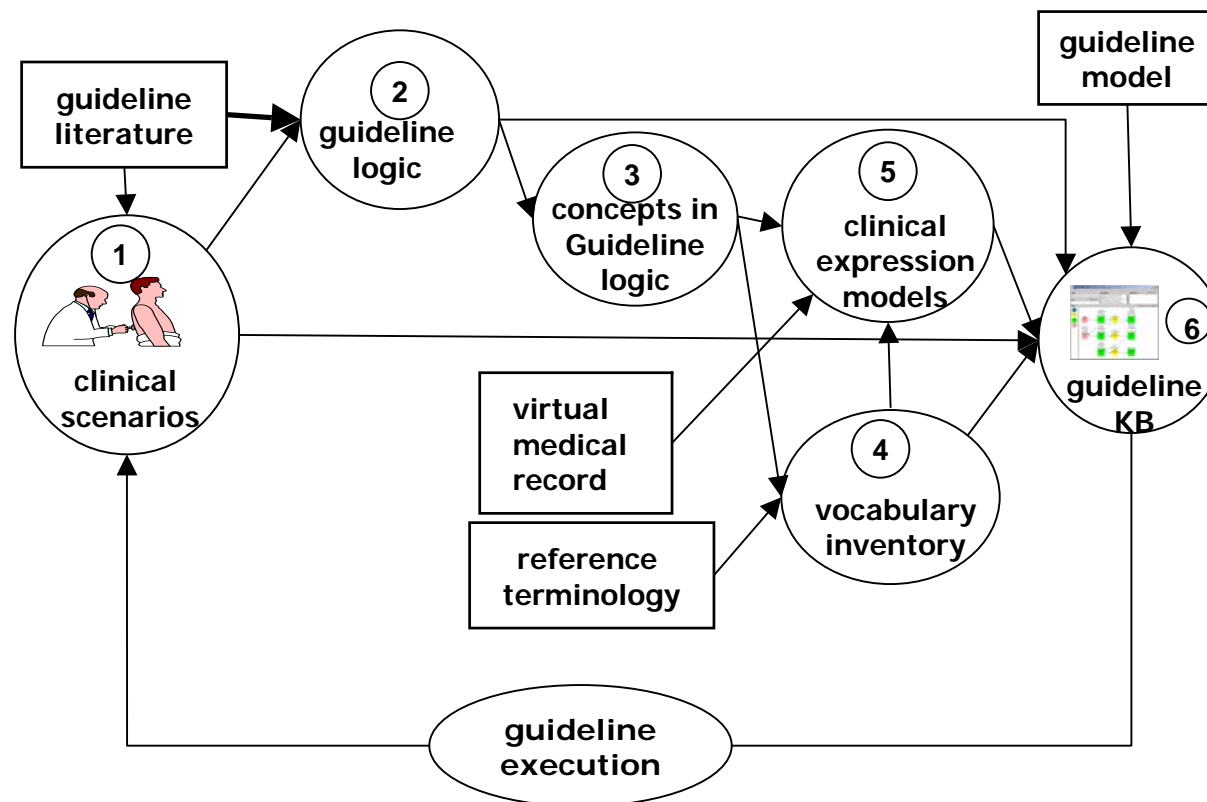
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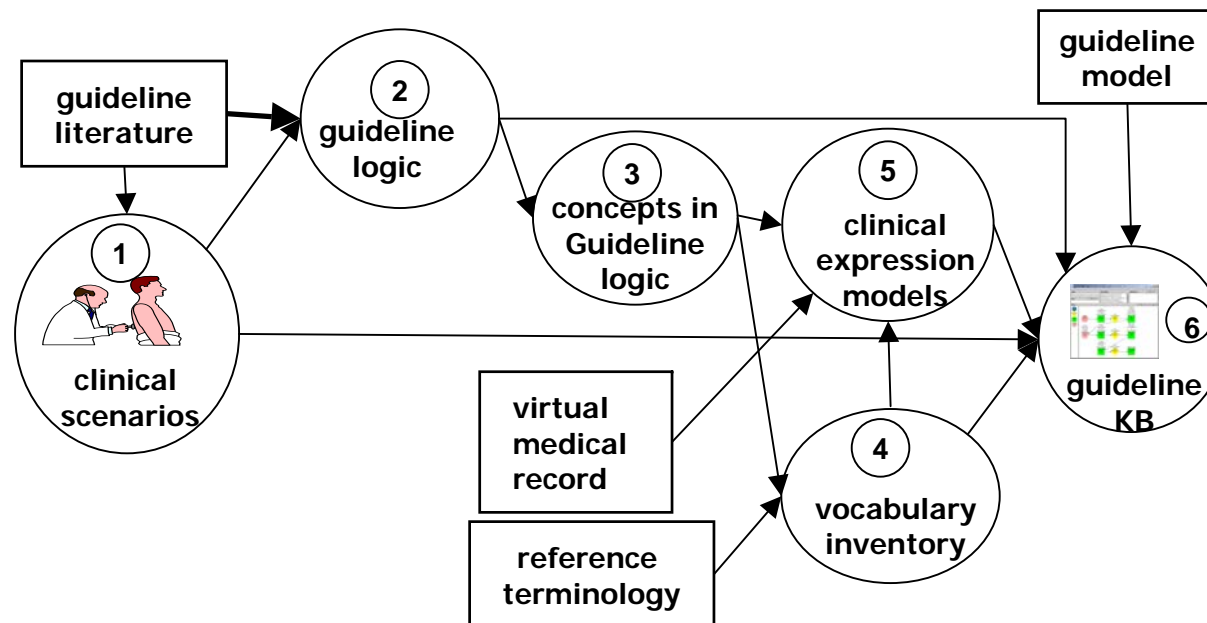
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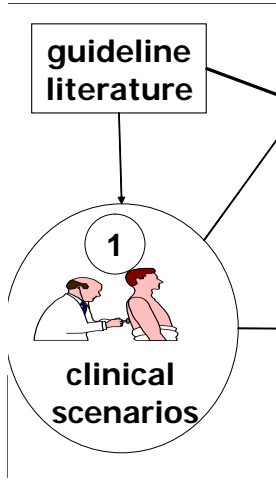


SAGE Approach: Deployment-driven Guideline Modeling



Today's Talk:





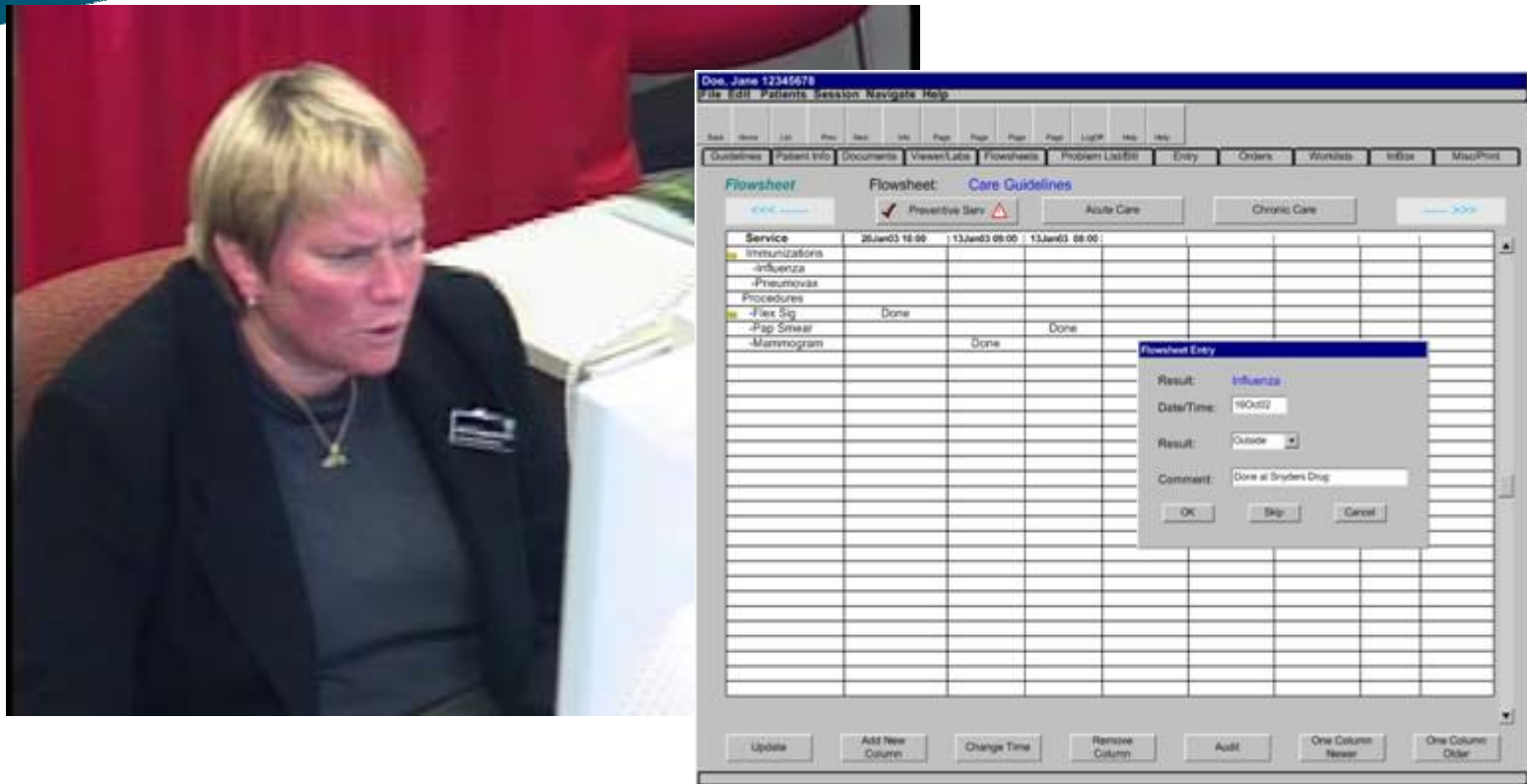
Deployment-Driven Guideline Modeling

- Assumption: Guideline DSS is reactive
 - Not in control of clinical workflow
 - Respond to external events (including passage of time)
- Methodology
 - Empirically define points in care processes where guideline DSS may provide services
 - Discover characteristics of human-computer interactions that enhances prospect of acceptance
- Method used in SAGE
 - Create scenarios that walk through steps of care process
 - Create prototype GUI for validation in usability lab

Scenario Example

- Patient arrives for visit with **primary physician**. At **check-in**, SAGE checks for immunizations that are due, alerts nurse, prints consents and information sheets. Nurse then reviews any other shots received, **updates the record**, and SAGE pre-order immunizations to be given that day

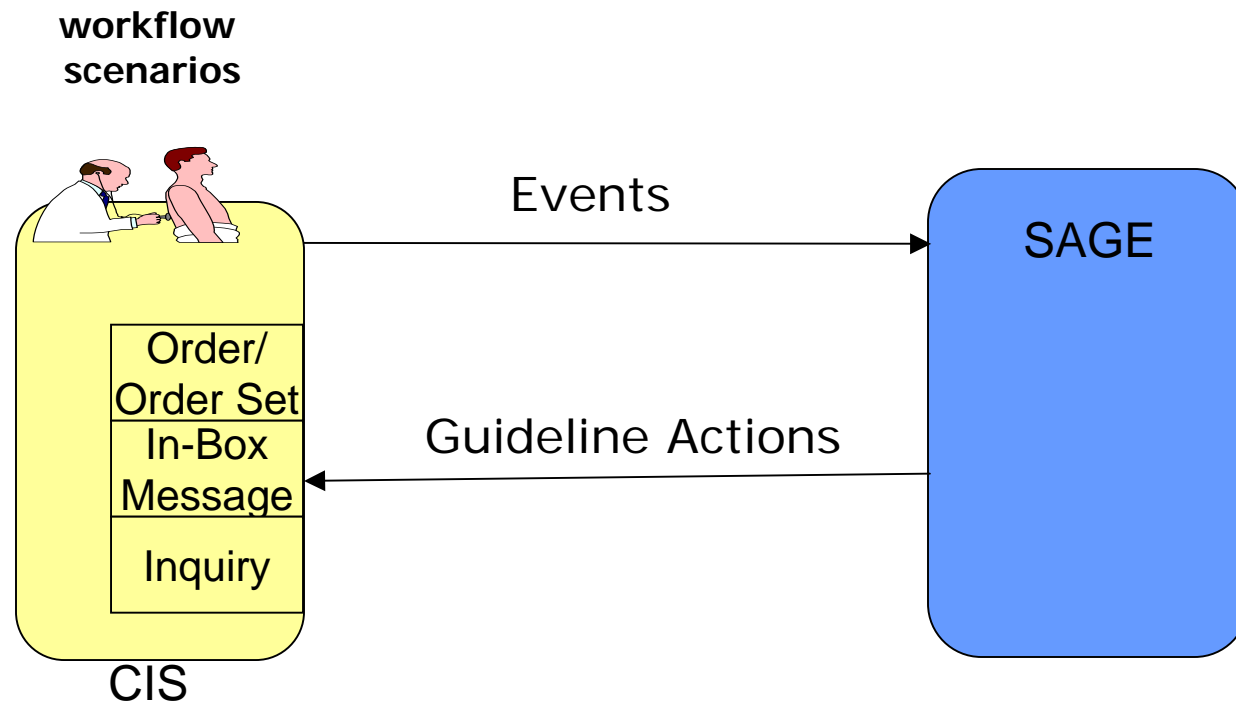
Usability Testing



- Develop mock-up forms with simulated decision-support interactions
- Prototypes tested by clinicians in Mayo usability lab

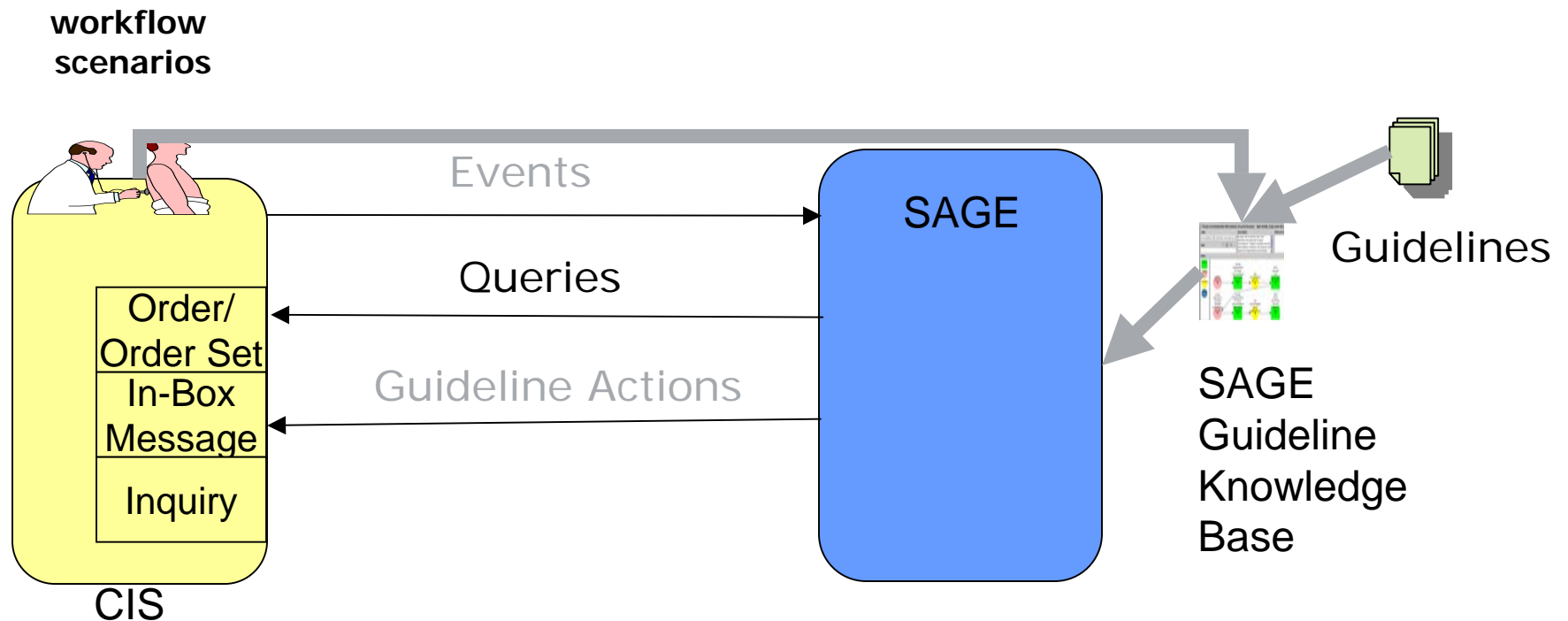
Results of Scenario Development

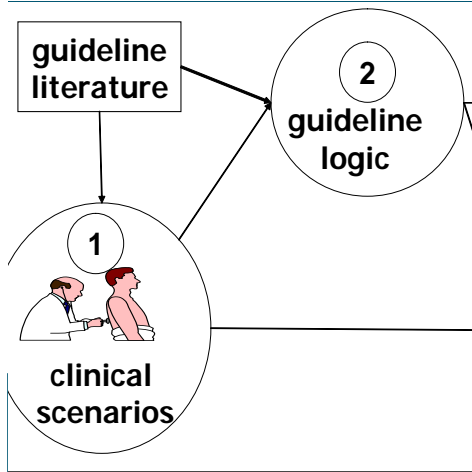
- Defines **events** that SAGE must respond to and **guideline-based actions** that SAGE should generate
- Defines **timing**, **form**, and **content** of decision-support services



Results of Scenario Development

- Defines events and actions that SAGE must respond to and generate
- Defines form and content of decision-support services
- Define what **guideline knowledge** must be encoded and what **data** must be queried.





Distillation of Guideline Logic

“checks for immunizations that are due”

IF AGE < 19 YEARS and
 no contraindication to Hep B
 AND
 No reason for deferral AND
 Number Hep B VACCINE
 DOSES=3 AND
 1ST DOSE GIVEN WITHIN
 7 DAYS OF BIRTH AND
 3RD DOSE GIVEN BEFORE 6
 MONTHS AGE AND
 TIME FROM LAST DOSE IS
 >= 8 WEEKS
 THEN
 ADVISE HEP B VACCINE DUE

Algorithm Annotations (cont)

7. Hepatitis B
 Children

All children not previously immunized should receive the Hepatitis B immunization in 3 0.5 mL doses given so that the first and second doses are given a minimum of 8 weeks apart, and the first and third doses are given a minimum of 16 weeks apart.

Annotation Appendix A – Recommended Catch-up Immunization Schedule/Minimum Intervals Between Vaccines for Children

For Children Who Start Late or Who Are >1 Month Behind

For any vaccine given in a series, it is not necessary to start over. Refer to the tables below for recommended “catch-up” schedule and minimum intervals between doses. Determine the number of previous doses of each vaccine received, find that number in the first column, and read across to the appropriate column for the next dose(s) and minimum interval(s).

Table 1. Catch-up schedule for children 4 months through 6 years - must be used with guidelines below

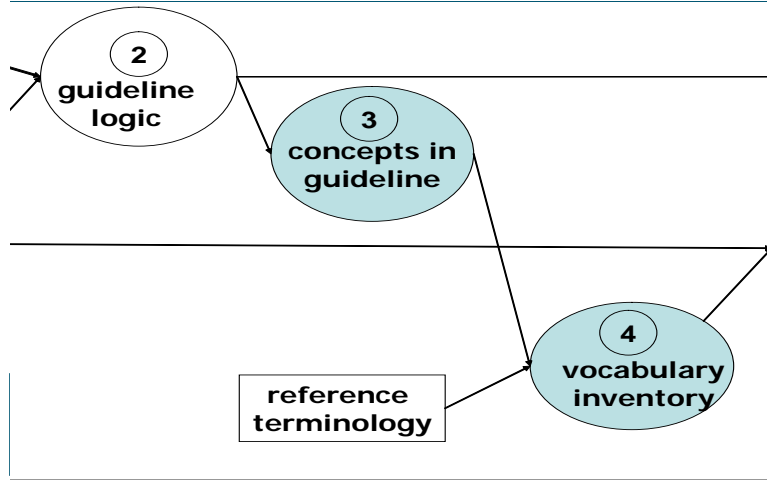
Number of previous doses of	Doses to be given and minimum intervals from previous dose
0	3 doses, 12 weeks apart
1	2 doses, 8 weeks apart
2	1 dose

Annotation Appendix C – Guide to Contraindications and Precautions to Immunizations

Guide to Contraindications and Precautions¹ to Commonly Used Vaccines

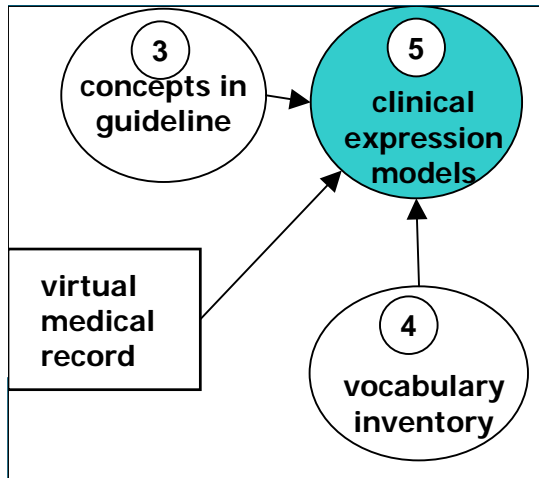
Vaccine	True Contraindications and Precautions ¹	Untrue (vaccines can be administered)
GENERAL FOR ALL VACCINES (DTaP,DT,Td,	Contraindications: + Serious allergic reaction (e.g., anaphylaxis) after a previous vaccine dose + Serious allergic reaction (e.g., anaphylaxis) to a vaccine constituent Precaution: Moderate or severe acute illness with or without fever	<ul style="list-style-type: none"> Mild acute illness with or without fever Mild to moderate local reaction (i.e., swelling, redness, soreness); low-grade or moderate fever after previous dose Lack of previous physical examination in well-appearing person Current antimicrobial therapy

Develop Vocabulary Inventory



- Guideline concepts must be extracted from guideline logic
- Guideline concepts need to be operationalized in terms of reference terminologies
 - Contextualization
 - De-abstraction
 - Disambiguation
- Reference terminologies need to be extended
 - Post-coordination
 - Concept expressions

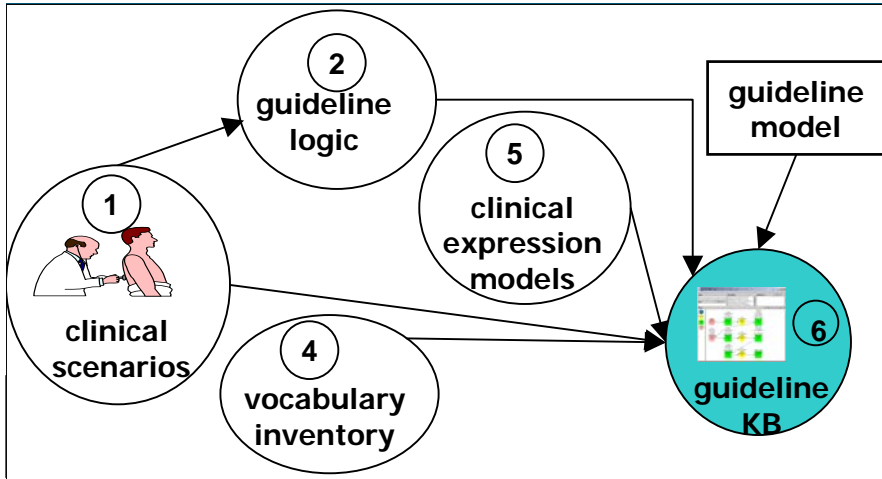
**chronic pulmonary disease excluding asthma =
(‘Chronic respiratory disease:
17097001’ AND
‘Disease of lower respiratory
system:128272009’) AND
NOT ‘Asthma:195967001’**



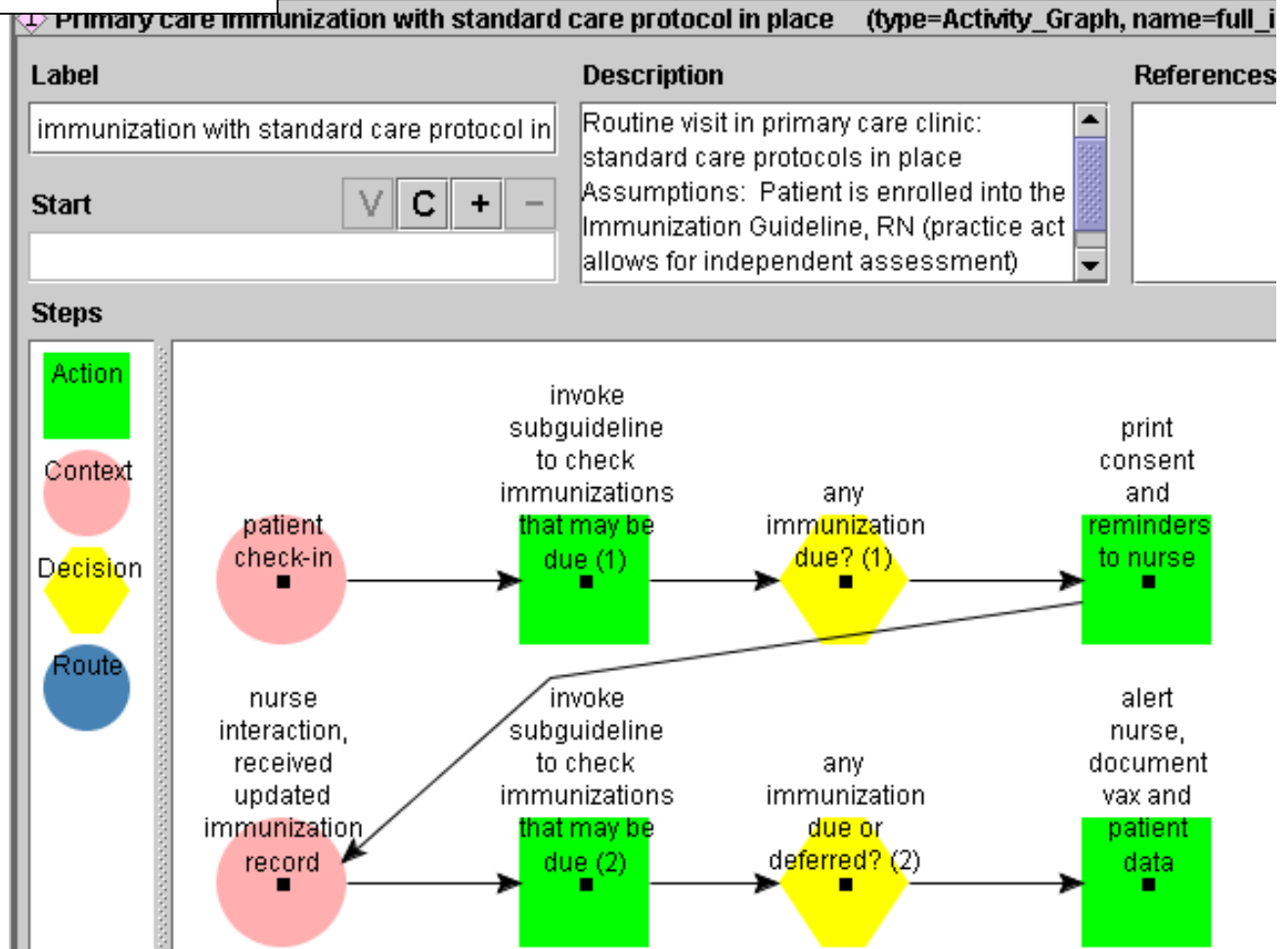
Define "Clinical Expression Models"

- How are statements about patient represented in a clinical information system (CIS)?
 - "Anaphylactic reaction to vaccine"
 - Virtual medical record (VMR): Simplified view of patient data used by the DSS
 - VMR class 'Allergy' class that has attributes such as 'code,' 'allergen,' 'reaction,' and 'effective time'
 - Clinical expression model Allergy where
 - code is 'vaccines allergy' (or its subconcepts)
 - allergen is 'vaccine' (or its subconcepts)
 - reaction is 'anaphylaxis' (or its subconcepts)

Guideline Encoding: Top-Level Workflow-Aware Process



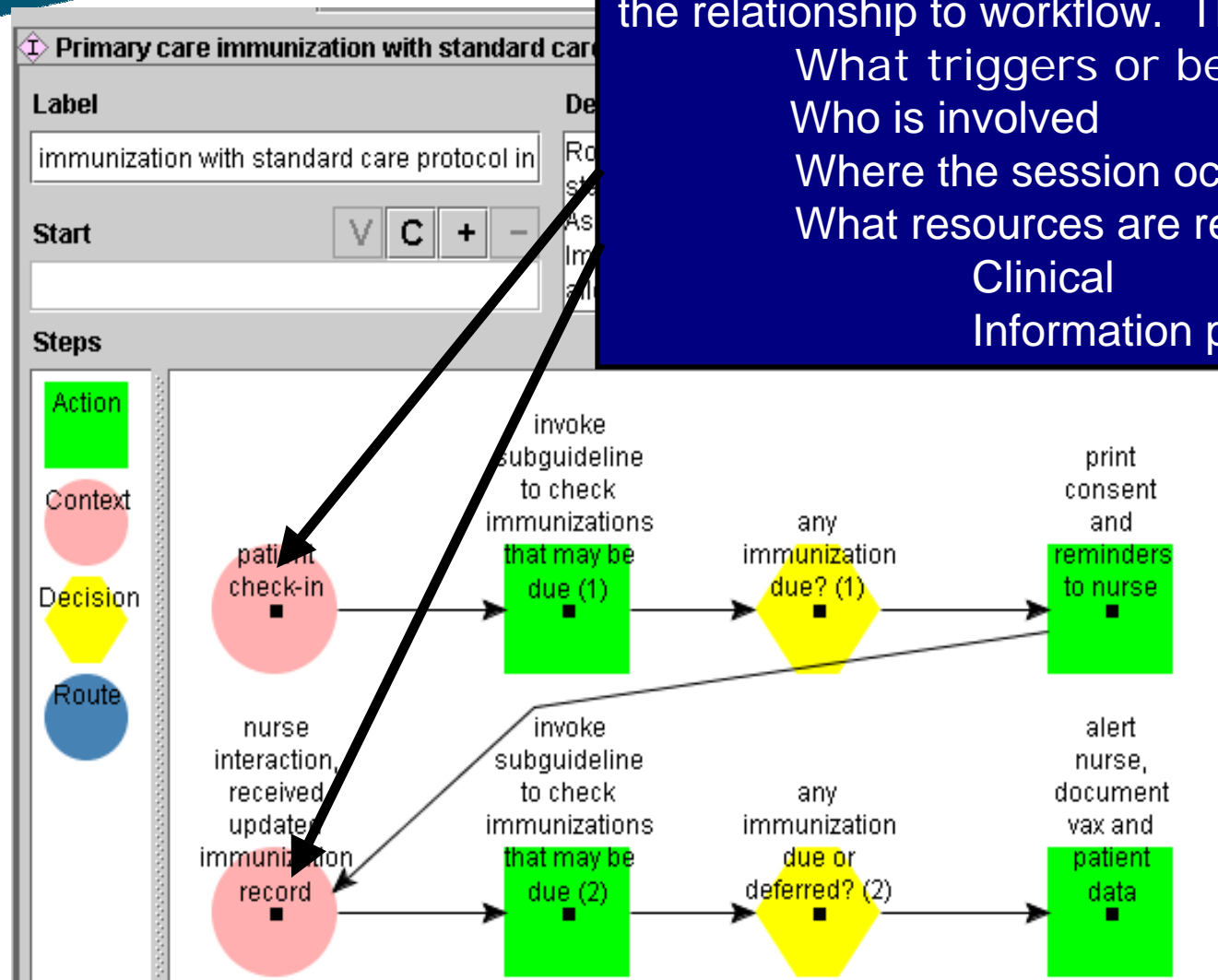
- Top-level process description in encoded guideline reflect expected reactions to events in clinical workflow



SAGE Context Model

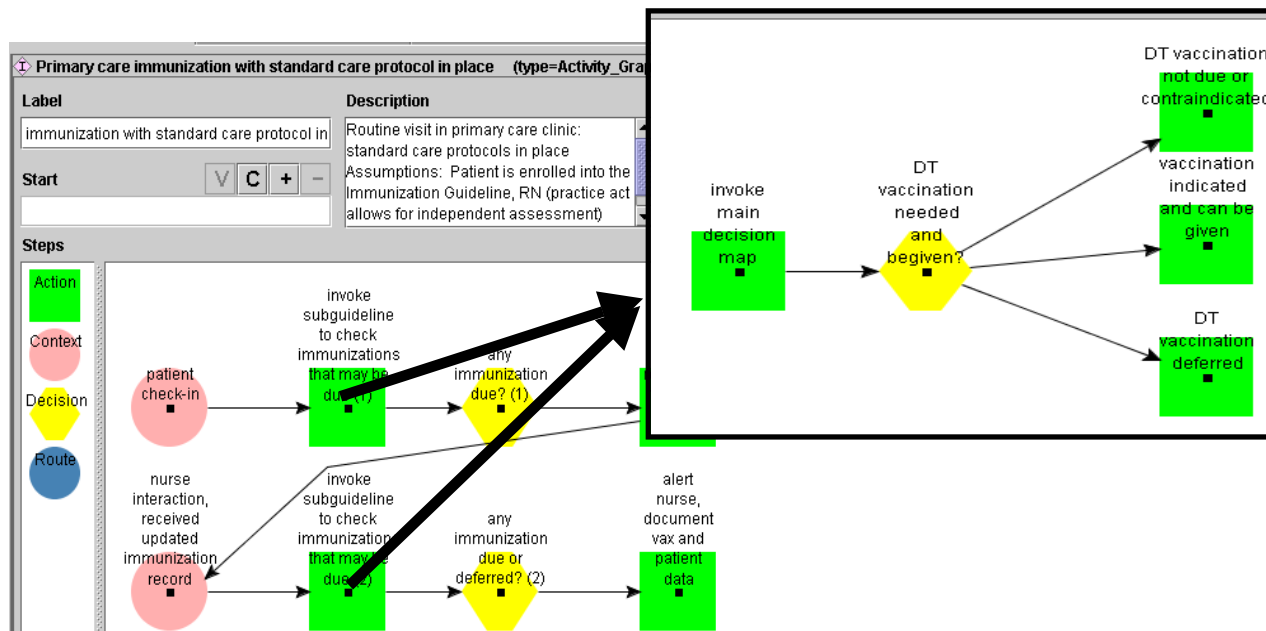
Context nodes organize and specify the relationship to workflow. They record:

- What triggers or begins session
- Who is involved
- Where the session occurs
- What resources are required
- Clinical
- Information processing



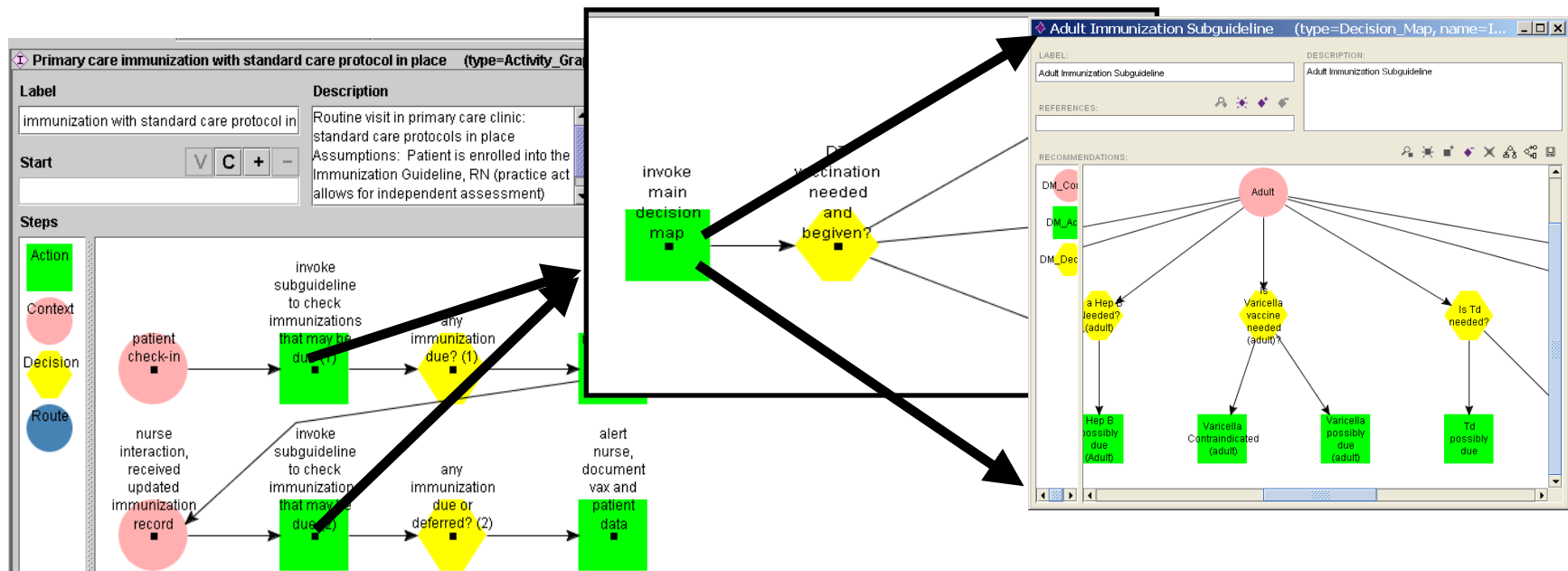
Decision Knowledge Encoded in Sub-guidelines

Can be thought of as reusable subsets of guideline logic for repeated use within a recommendation set



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Results

- Applied methodology (including execution stage) to exemplar guidelines:
 - Immunization, diabetes (completed)
 - Community-acquired pneumonia (in progress)
- Retrospectively verified that the deployment-driven methodology is consistent with the development process of the ATHENA hypertension DSS

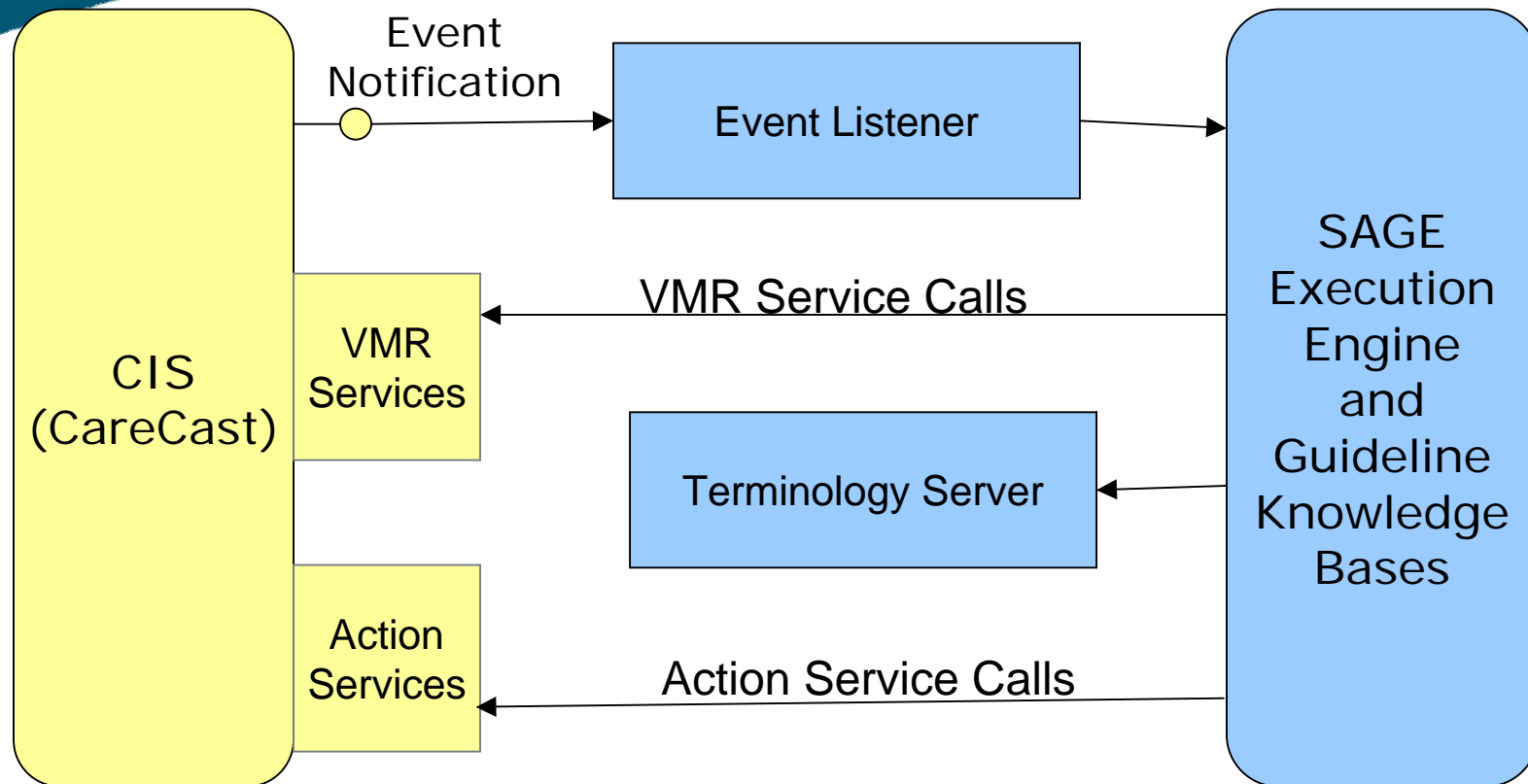
Discussion

- “Deployment-driven” guideline modeling versus “document-driven” guideline modeling
 - Encoding of narrative guideline for decision-support use cases is a highly selective process
 - Necessary medical knowledge is synthesized from different parts of a guideline and from multiple sources
- Top-level process descriptions in executable guideline are highly dependent on workflow
 - Contrast: GLIF modeling assume successive refinement from high-level conceptual flowchart to computable formalism and finally to implementation



Thank you

Integration of SAGE Decision-Support System with Clinical Information System



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