

Executing Clinical Practice Guidelines Using the SAGE Execution Engine

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Sharable Active Guideline Environment

- An R&D consortium to develop the technology infrastructure to enable computable clinical guidelines, that will be shareable and interoperable across multiple clinical information system platforms
- Scope: 3 year, \$18 M, multi-site, collaborative project
- Partners in the project are:
 - IDX Systems Inc.
 - Apelon, Inc.
 - Intermountain Healthcare
 - Mayo Clinic
 - Stanford Medical Informatics
 - University of Nebraska Medical Center
- Funded in part by: NIST Advanced Technology Program

Agenda for Today

- Overview of SAGE Project
 - Vision
 - Objectives
 - Architecture
- Overview of SAGE guideline execution
 - Overview of guideline encoding model
 - Guideline execution architecture
 - Highlights of guideline execution

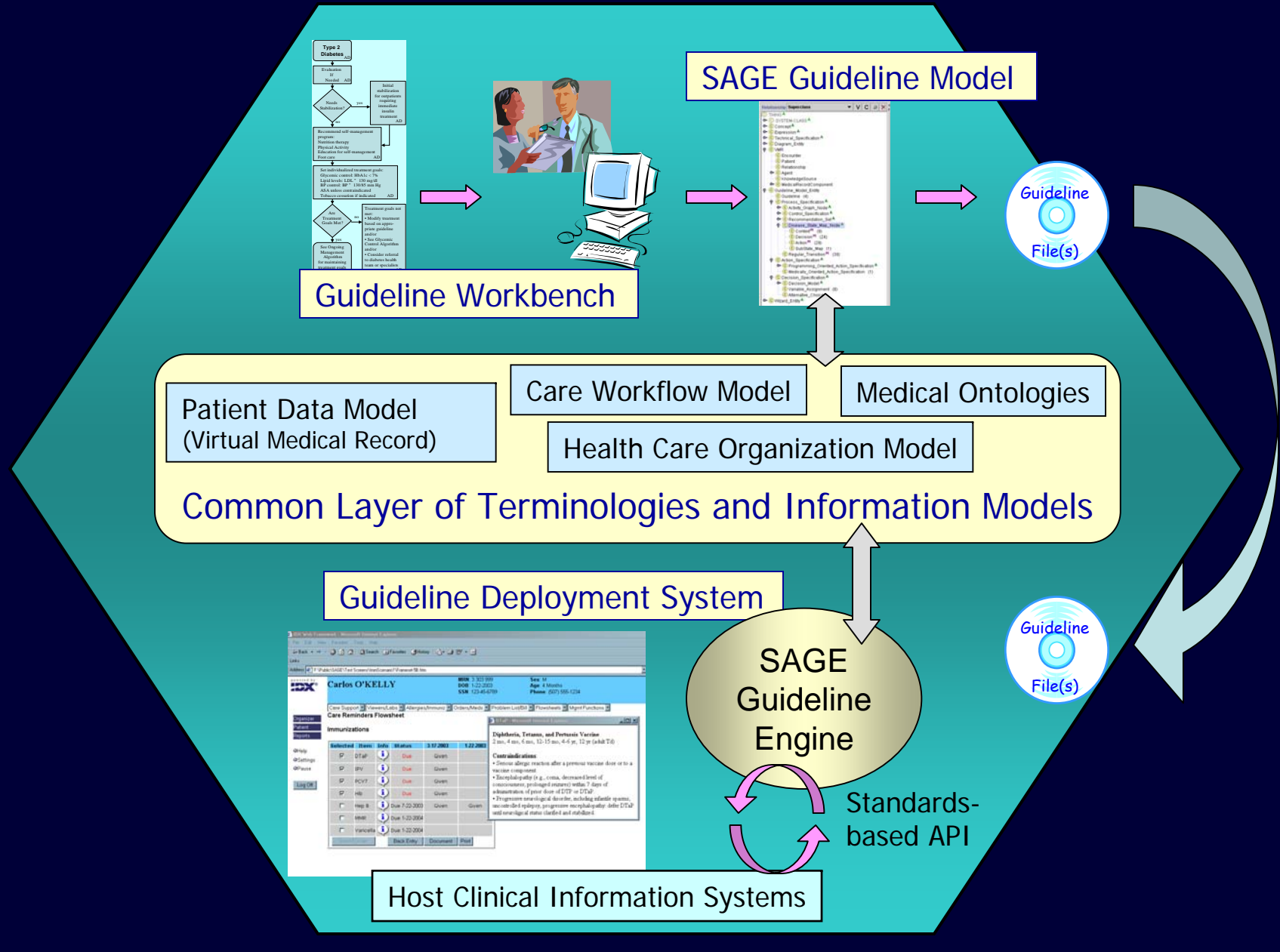
SAGE Interoperability Goals

6 months \leq time to import new rule \leq never

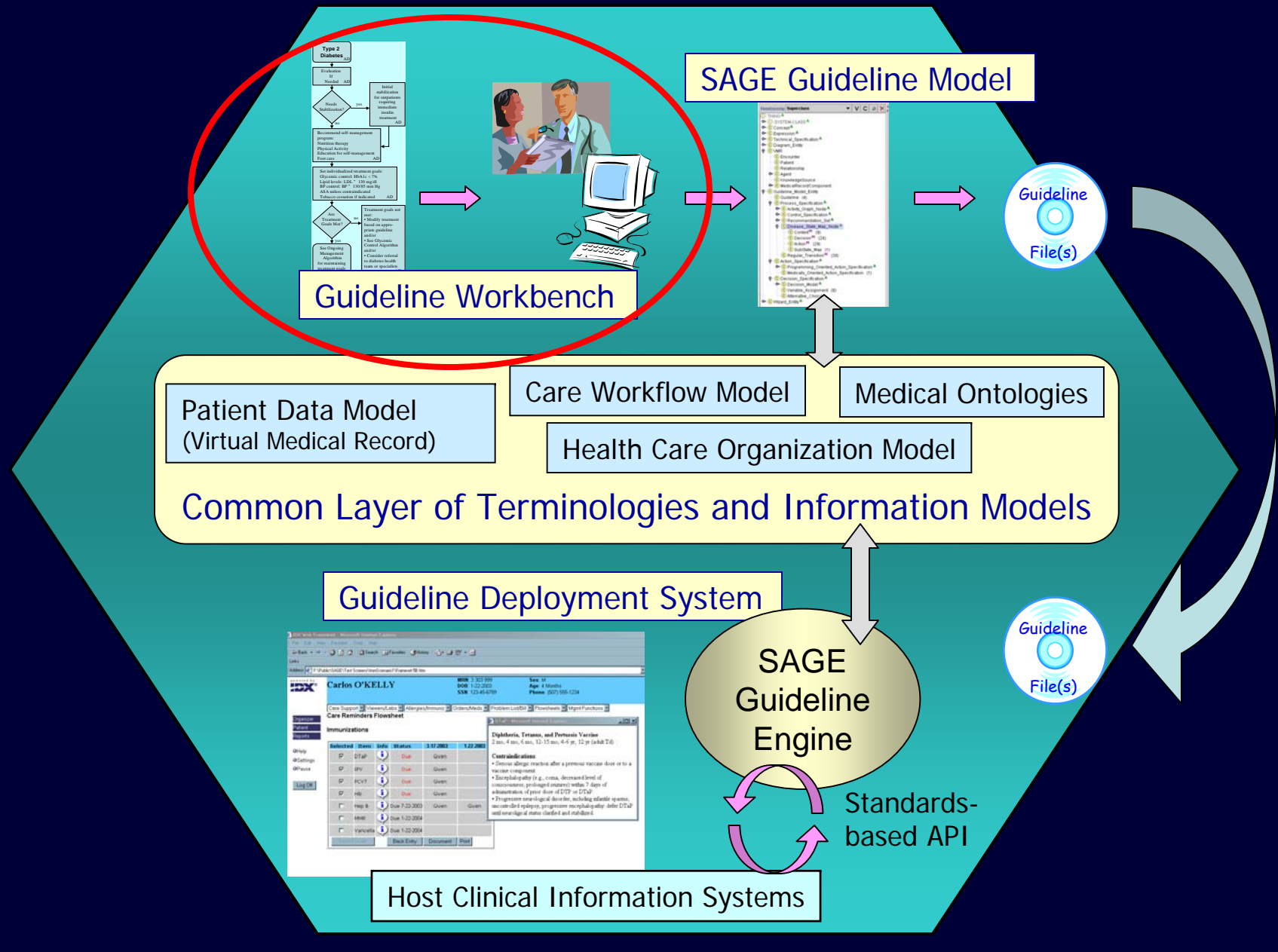
A technology infrastructure that supports:

- Clinical practice guidelines – encoded in a computable, standards-based representation.
- Once encoded, guideline content can be deployed to multiple different clinical information system platforms.
- Surfacing guideline content via functions and user interface native to the local CIS.
- Allows different institutions to share guideline content and knowledge bases
- “*Write once, distribute quickly, use widely*”

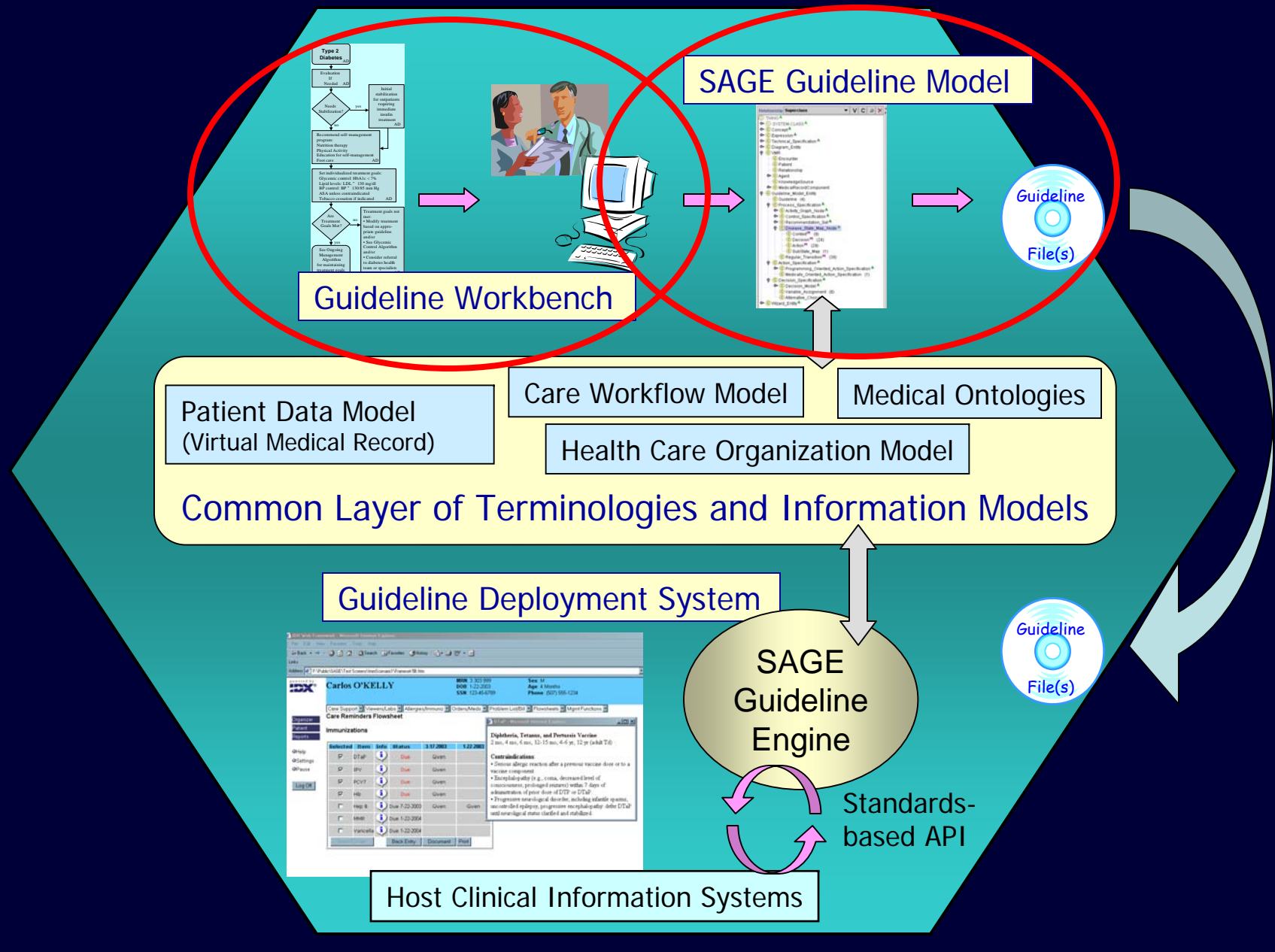
Overview of the SAGE Infrastructure



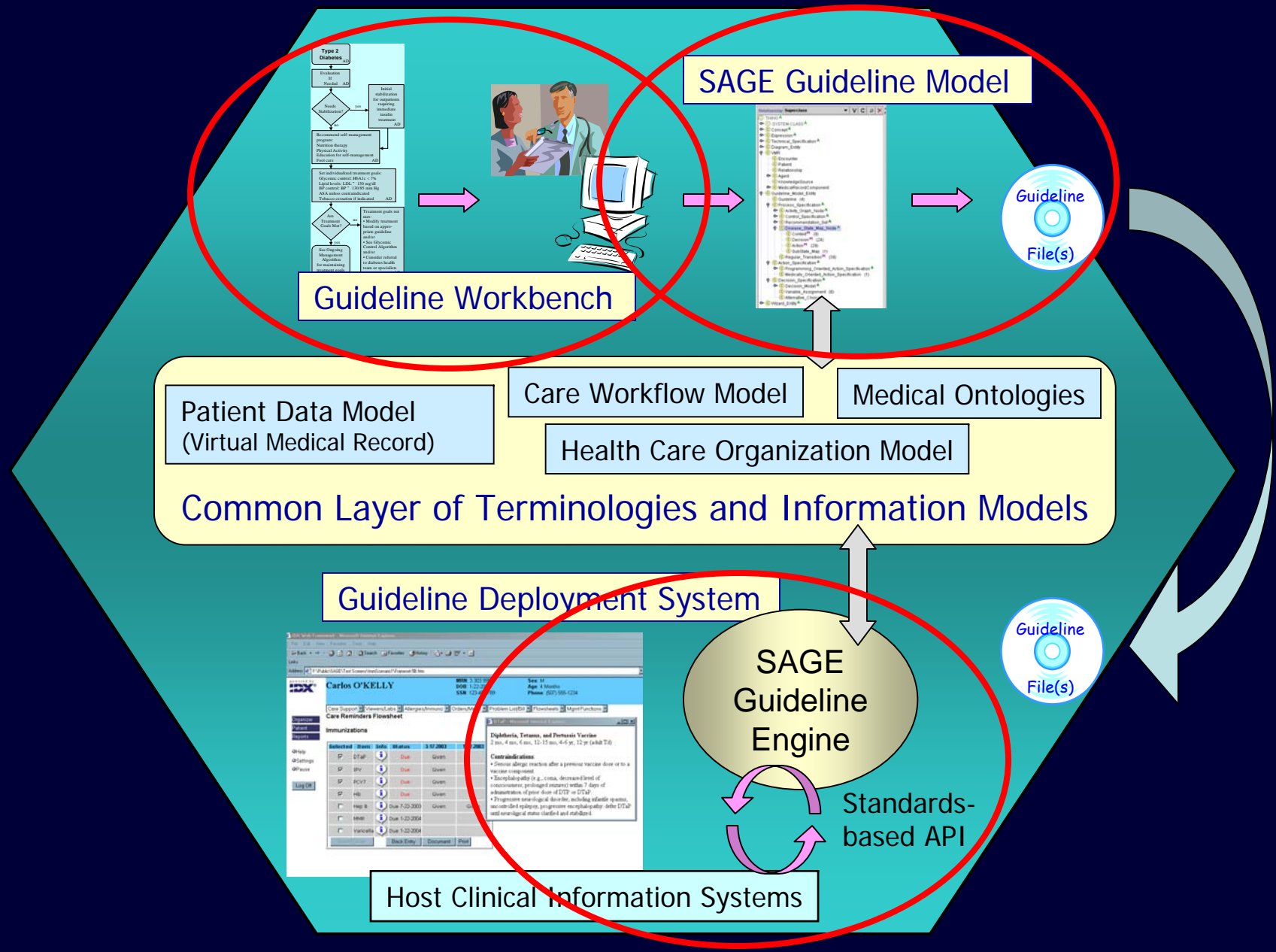
Overview of the SAGE Infrastructure



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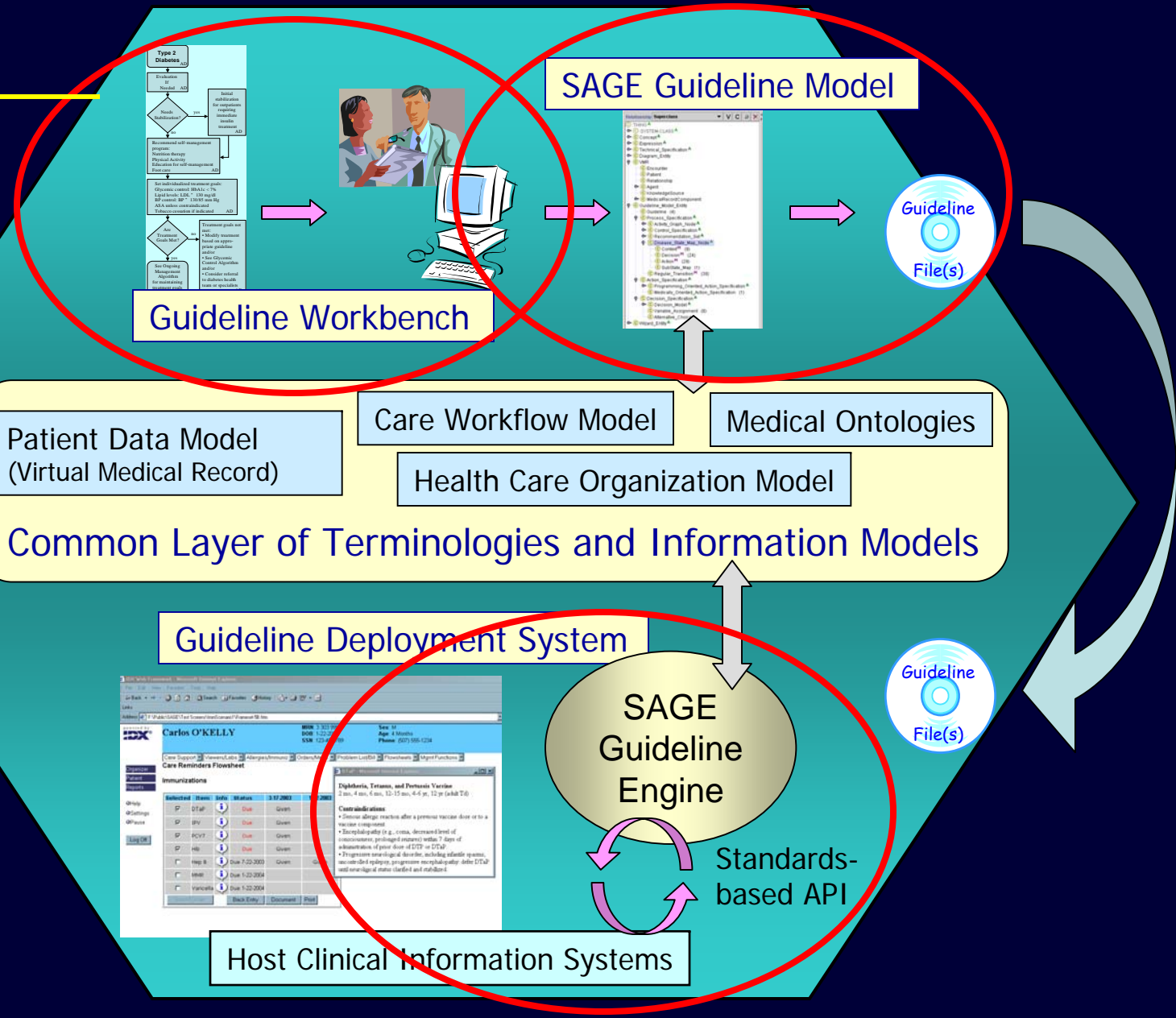
Overview of the SAGE Infrastructure



Overview of the SAGE Infrastructure

1:15PM

S 046



Overview of the SAGE Infrastructure

1:15PM

S 046

SAGE Guideline Model

3:15PM

S 059

Guideline Workbench

Patient Data Model (Virtual Medical Record)

Care Workflow Model

Medical Ontologies

Health Care Organization Model

Common Layer of Terminologies and Information Models

Guideline Deployment System

SAGE Guideline Engine

Standards-based API

Host Clinical Information Systems

Guideline Scenario:

Diabetes Mellitus – Primary Care Visit

The patient is an elderly man with longstanding Type II Diabetes Mellitus. Comorbidities include hypertension (well-controlled) and hyperlipidemia (marginally controlled). He reports for a routine clinic visit with his primary care doctor.

Triggered by clinic check-in and the presence of diabetes on the problem list, guideline logic activates, automatically enrolls the patient on the diabetes guideline, and then checks to see if vitals and home glucose measurements have been entered. If not, the nurse is prompted to collect this information.

After required information is entered, the guideline resumes execution, queries patient EMR data, and evaluates decision logic – resulting in:

- Setting and evaluation of clinical goals for this patient.
- Notifications to clinicians (e.g., “*HbA1C not in control*”),
- Pending orders for lab tests, medications, and for diabetes education.
- Referrals for specialty treatment (e.g., Cardiology)



Guideline Scenario:

We envision the clinical context

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Guideline recommendations are “channeled” via CIS functions

SAGE Guideline Representation: An Overview

Context Nodes organize and specify the relationship to workflow.

- What triggers the session
- Who is involved
- Where the session occurs

Adult
Diabetes
Patient

Decision Nodes provide support for making choices:

- Specification of alternatives
- Logic used to evaluate choices
- Can change the clinical workflow

When
should
lipid labs
be
ordered?

Action Nodes define activity to be accomplished by CIS:

- User interaction, query, messaging
- Order sets
- Appointments and referrals
- Goal setting
- Documentation and recording

Order lipid
labs 12
months
from last
labs

Order lipid
labs 24
months
from last
labs

Order lipid
labs for 3
months
from last
labs

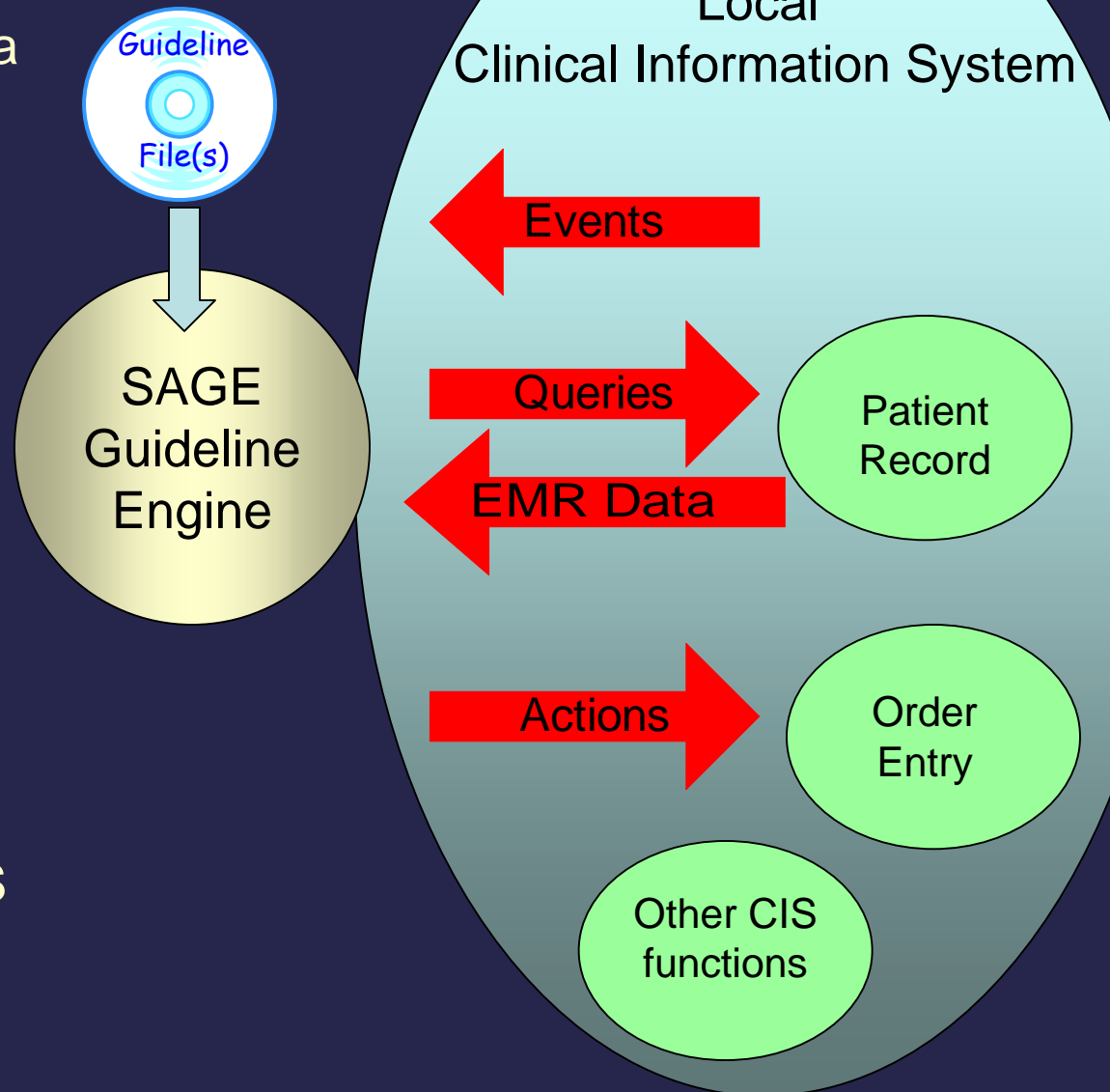
The guideline has been encoded. **Now what?**

Initial “set up” and preparation work:

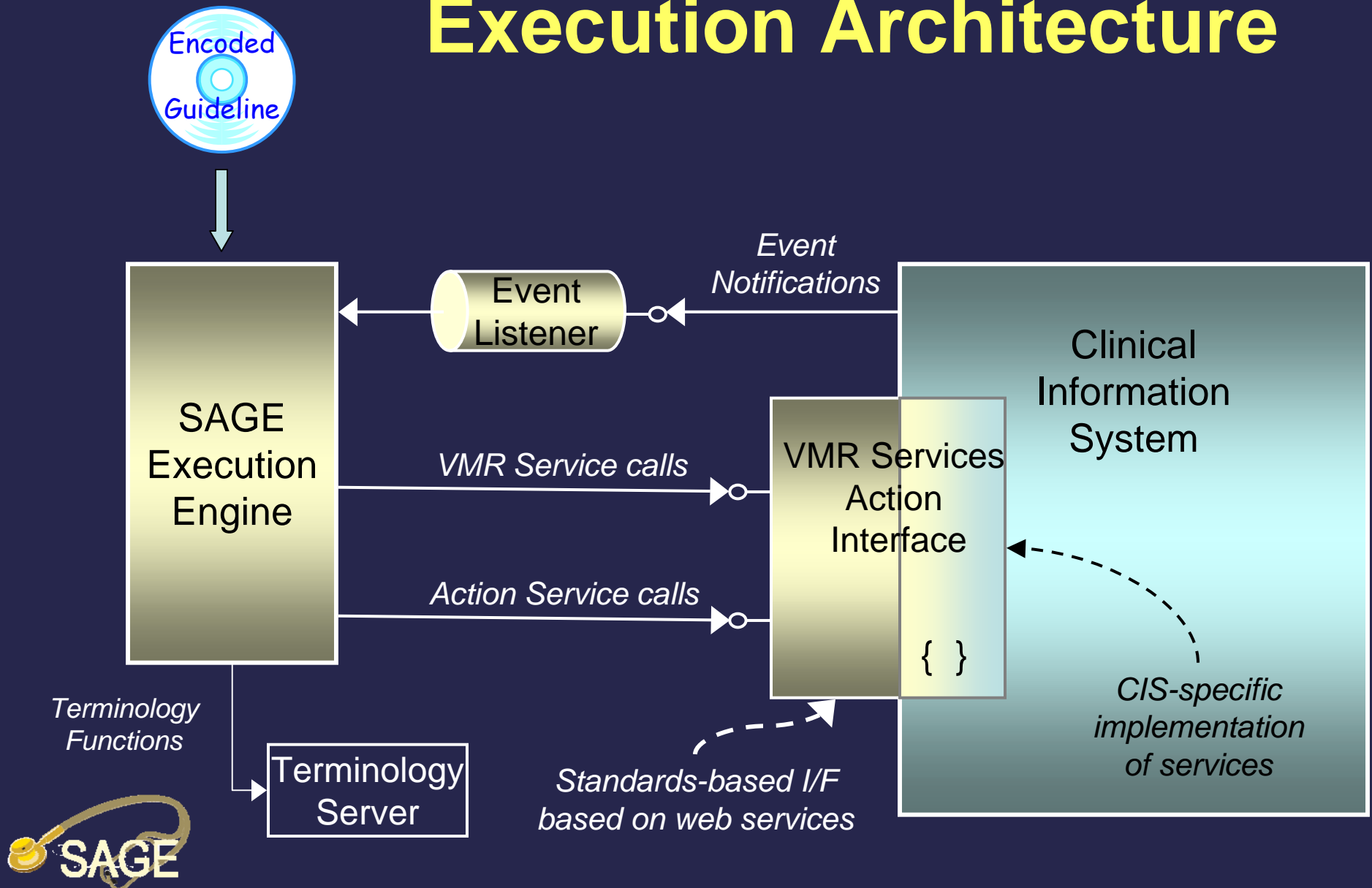
- Guideline downloaded to local system
- Guideline reviewed by medical staff
(assess recommendations, workflow, etc.)
- Guideline is “localized”
(edited for local conditions, restrictions, whim . . .)
- Interfaces and services installed
(CIS – specific “binding” and terminology mapping)
- Guideline activated

How does SAGE interact with clinical information systems ?

- It communicates with CIS via standards-based interfaces
- It detects events in the clinical workflow (e.g. patient is admitted)
- It queries data from the CIS electronic medical record (e.g. age)
- It executes guideline logic based on patient specific data
- It makes real-time, patient-specific recommendations via functions of the local CIS

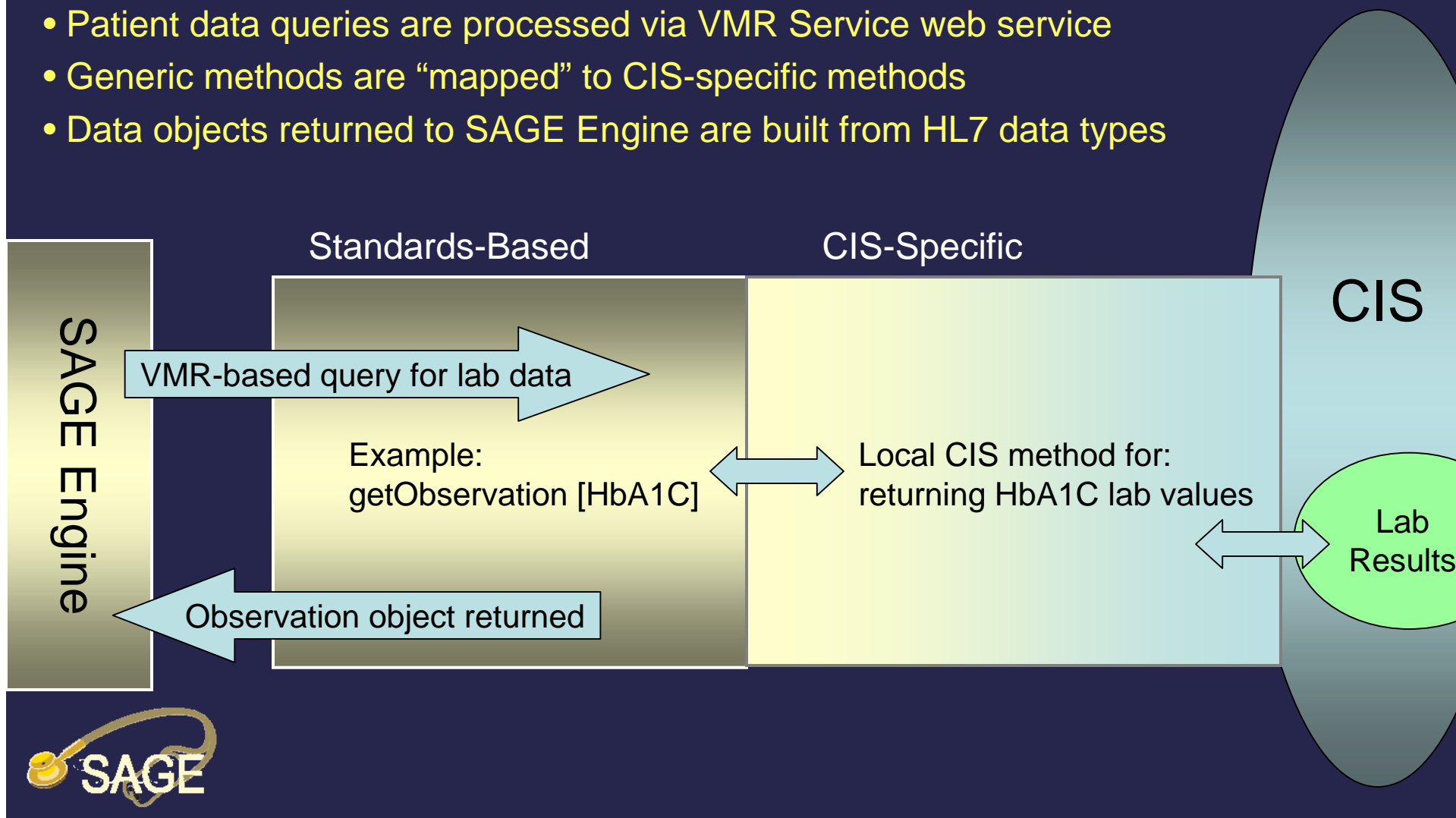


SAGE Guideline Execution Architecture



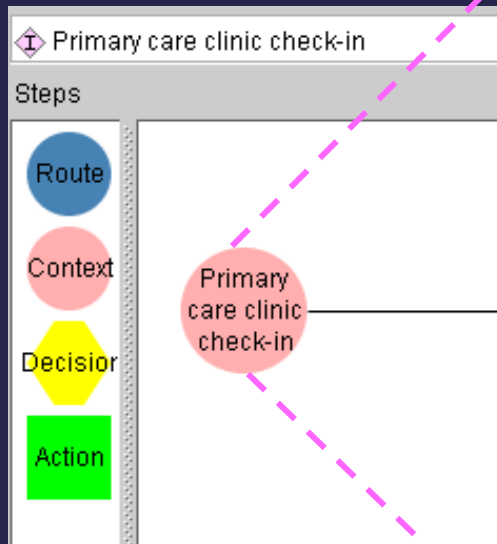
VMR Services Interface

- In the guideline model, patient data concepts are represented using VMR classes
- Queries for patient data are represented using standard VMR-based methods
- Patient data queries are processed via VMR Service web service
- Generic methods are “mapped” to CIS-specific methods
- Data objects returned to SAGE Engine are built from HL7 data types



Guideline Execution:

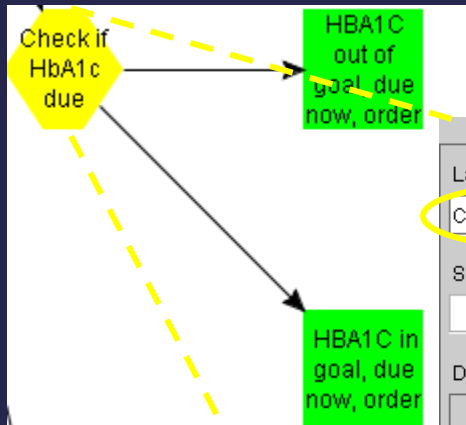
SAGE listens for and detects context-specific events



Label		Triggering Events
Primary care clinic check-in		<input checked="" type="radio"/> Outpatient clinic check-in event
Scheduling Constraint		
Clinical Context		Description This is the Context in which a patient checks in to their primary care clinic.
out patient primary-care clinic		
Informatics Context		
Precondition		References
Diabetes Mellitus on Problem List		
Automation Mode		
automatic start and finish		
Transition Restriction		
XOR join AND split		
Subguideline		<input checked="" type="checkbox"/> New Session

Guideline Execution:

SAGE executes encoded decision logic

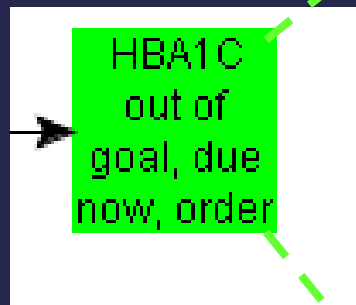


SAGE will query the patient EMR as necessary, and evaluate all decision criteria

The screenshot shows the SAGE decision logic interface. The "Label" field is "Check if HbA1c due". The "Scheduling Constraint" field is empty. The "Decision Model (1 values)" field is empty. The "Alternatives" field contains two items: "HBA1C out of goal, due now, order" and "HBA1C in goal, due now, order". The "Transition Restriction" field is "XOR join XOR split". The "Automation Mode" field is "automatic start and finish". The "Description" field contains the text: "If HbA1C is out of goal, it must be measured every 3 months; if in goal, every 6 months." The "References" field is empty. The "Strength Of Evidence" field is empty. The "Recommendation Threshold" field is "3". The "Strict Rule Out" field is empty. The "Strict Rule In" field contains three items: "A1C not obtained in last 3 months", "A1C not ordered in next month", and "HbA1C is out of goal range". The "Rule Out" field is empty. The "Rule In" field is empty. The "Evidences" field is empty.

Guideline Execution:

SAGE communicates actions to the CIS



Label	Triggering Events
HbA1C out of goal, due now, order	
Scheduling Constraint	
Repeat Expression	
Description	Place order request for HgA1c
Action Spec	
Order HbA1C	
Inform PCP HbA1c is out of goal and due	
Termination Condition	
Automation Mode	
automatic start and finish	
Transition Restriction	
XOR join XOR split	
Subguideline	

01000231 WHITE, Betty - F

File Patient Session Navigate Help

Demog Orders Results Viewer Allergies Pathways Pharmacy Care Mgmt Setup Notes Med Profile Microbiology Res...

Desktop

Current Patient List: GRP: SAGEdiabetes Sage

MRN	Patient Name	Other Information
01000215	ANDERSON, John	
01000207	STOCK, Marie	
01000223	THOMPSON, Bill	
01000231	WHITE, Betty	

Select Remove Add Active Find.. Temp List Print List Refresh

Command Central

Command:

Active MRN: 01000231

Patient List Directory

☒ Freq ☐ Folders ☐ Avail

List Name	Type	Owner
Hotlist ♥		
SAGEdiabetes	GRP	Sage
SAGEimmunization	GRP	Sage

Select Make Default Make Freq Move/Remove

InBox Messages

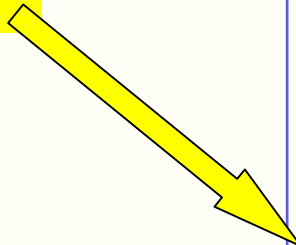
All Mine Patient

Notifications	Count
EO Related	
LEO forwarded orders	2
SAGE Messages	
Message from SAGE Engine	1

Create Resolve Refresh Sage

ATTENDING... .SAGMD 14Jul1925 Tue 79 0.8 LWGH

SAGE guideline execution has generated patient-specific notifications to care providers



01000231
File Patient Session Navigate Help

Demog Orders Results Viewer Allergies Pathways Pharmacy Care Mgmt Setup Notes Med Profile Microbiology Res...

Notification: Message from SAGE Engine

Date	Time	Subject	From	FYI	Note
31Aug2004	11:02	Sage Mesg.	SAGE, USER		

Annotate
Audit
Forward
Hold
Assign
Reject
Reply
Resolve
Cancel

subject: Aspirin recommendation
message: This patient has indications for aspirin therapy, and has not been prescribed aspirin. Please consider starting aspirin therapy at 75 to 325 mg/day.

subject: Inform clinician that BP is missing
message: No blood pressure has been recorded for this patient today. This information is necessary for evaluation.

message: This patient's HbA1C is out of goal range."

subject: Prompt physician to indicate whether cardiovascular signs/sx present
message: New CV signs/sx?

subject: Recommend referral to nephrologist if indicated
message: Consider referral to a nephrologist. (Please see indications)

subject: If HbA1C is out of goal range, notify physician via inbox
message: This patient's HbA1C is out of goal range.

subject: Suggest adding Hyperlipidemia to problem list via inbox
message: Consider adding Hyperlipidemia to Problem List

Forwarded/Reassigned By: SAGE, USER

Reason for Forward/Reassign

Full Subject Text: Sage Mesg.

ATTENDING... INBRES01 14Jul1925 Tue 79 0.3 LWGH



SAGE guideline execution has caused 7 pending orders to be created in the CIS

FlowSheet Index - Microsoft Internet Explorer

File Edit View Favorites Tools Help

<input type="checkbox"/>	Resp (BREATHS/MIN)					22	20		20
<input type="checkbox"/>	Temp (DEGREEEC)					36.0	37.0		37.0
Information Required									
Goals									
<input type="checkbox"/>	New CV signs/sx? ()			Due now					
<input type="checkbox"/>	Tobacco use status? ()			Due now					
<input type="checkbox"/>	Foot exam ()			Due now					
Diabetes Mellitus									
Assessment									
<input type="checkbox"/>	Home Glucose High (mg/dl)								120
<input type="checkbox"/>	Home Glucose Low (mg/dl)								85
<input type="checkbox"/>	Smoker/Tobacco use								
<input type="checkbox"/>	Foot Exam								norm
<input type="checkbox"/>	Annual Retinal Exam								
<input type="checkbox"/>	Cardiac Stress Test								
Lab Tests									
<input type="checkbox"/>	HbA1c (%)	< 7.0		Due now				7.5	7.5
<input type="checkbox"/>	Fasting BG (mg/dl)								
<input type="checkbox"/>	Total Cholesterol (MG/DL)								
<input type="checkbox"/>	HDL (MG/DL)	> 45.0	i	Due now					
<input type="checkbox"/>	LDL (MG/DL)	< 100.0	i	Due now					
<input type="checkbox"/>	TGL (MG/DL)	< 150.0	i	Due now					
<input type="checkbox"/>	Creatinine (mg/dl)								
<input type="checkbox"/>	Urine Microalbumin (mg/24 h)								
Education									
<input type="checkbox"/>	Diabetes Self-Care								
<input type="checkbox"/>	Nutrition counseling								

Save Acknowledge Subm

Done Internet

SAGE guideline execution can populate a patient-specific clinical care "flowsheet" with guideline recommendations, goals, and reference information.

General Info

- ☐ Height (CM)
- ☐ Weight (KG)
- ☐ Systolic BP (MM
- ☐ Diastolic BP (M
- ☐ HR (BEATS/MIN)
- ☐ Resp (BEATS/MIN
- ☐ Temp (DEGREEC)

Information Required

- ☐ New CV signs/sx
- ☐ Tobacco use sta
- ☐ Foot exam ()

Diabetes Mellitus

Assessment

- ☐ Home Glucose Hi
- ☐ Home Glucose Lo
- ☐ Smoker/Tobacco
- ☐ Foot Exam
- ☐ Annual Retinal
- ☐ Cardiac Stress Test

Tests

<input type="checkbox"/> HbA1c (%)	< 7.0	i	Due	7.5	7.5	7.5
<input type="checkbox"/> Fasting BG (mg/dl)						
<input type="checkbox"/> Total Cholestrol (MG/DL)						
<input type="checkbox"/> HDL (MG/DL)	> 45.0	i				
<input type="checkbox"/> LDL (MG/DL)	< 100.0	i	Due now			135 1 of 2

Rationalé for patientId : 658 - Microsoft Internet Explorer

Conclude HbA1C due 3 months from last measurement

Criteria Evaluated:

HbA1C has not been obtained:false
HbA1C within goal:false
No existing order for HbA1C:true

Actions taken:

Check when HbA1C due and whether out of goal

Action Specs executed:

Order HbA1C 3 months from last measurement
Conclude HbA1C due 3 months from last measurement

Criteria Evaluated:

HbA1C has not been obtained:false
HbA1C within goal:false
No existing order for HbA1C:true

Recommendation Backing:

Haemoglobin A1c (HbA1c) should be measured at 2-6 monthly intervals; the interval should depend on: acceptable levels of control, D and stability of blood glucose control, D and/or change in levels of blood glucose, D and/or change in therapies. D Six-monthly measurements should be made if the blood glucose level and blood glucose therapy are stable. D Resource:ADA Diabetes Care Guideline

Conclusions

Actions

Rationale

SAGE guideline execution can support display of guideline rationale, accompanied by patient-specific clinical logic.

Summary of Feasibility Demonstration

We have:

- Shown that clinical guidelines can be encoded in a standards-based, sharable, computable format.
- Demonstrated the capability to represent complex guideline content and logic for both acute and chronic care domains.
- Used standard information models and terminologies to support interoperable transfer of medical knowledge.
- Addressed interoperability goals via:
 - A standards-based guideline model
 - A VMR-based interface to CIS
 - Standard web services to access EMR data
 - Standards based access to terminology services

Executing Clinical Practice Guidelines Using the SAGE Execution Engine

Questions ?

Really hard technical stuff:

prabhu_ram@idx.com

Project management:

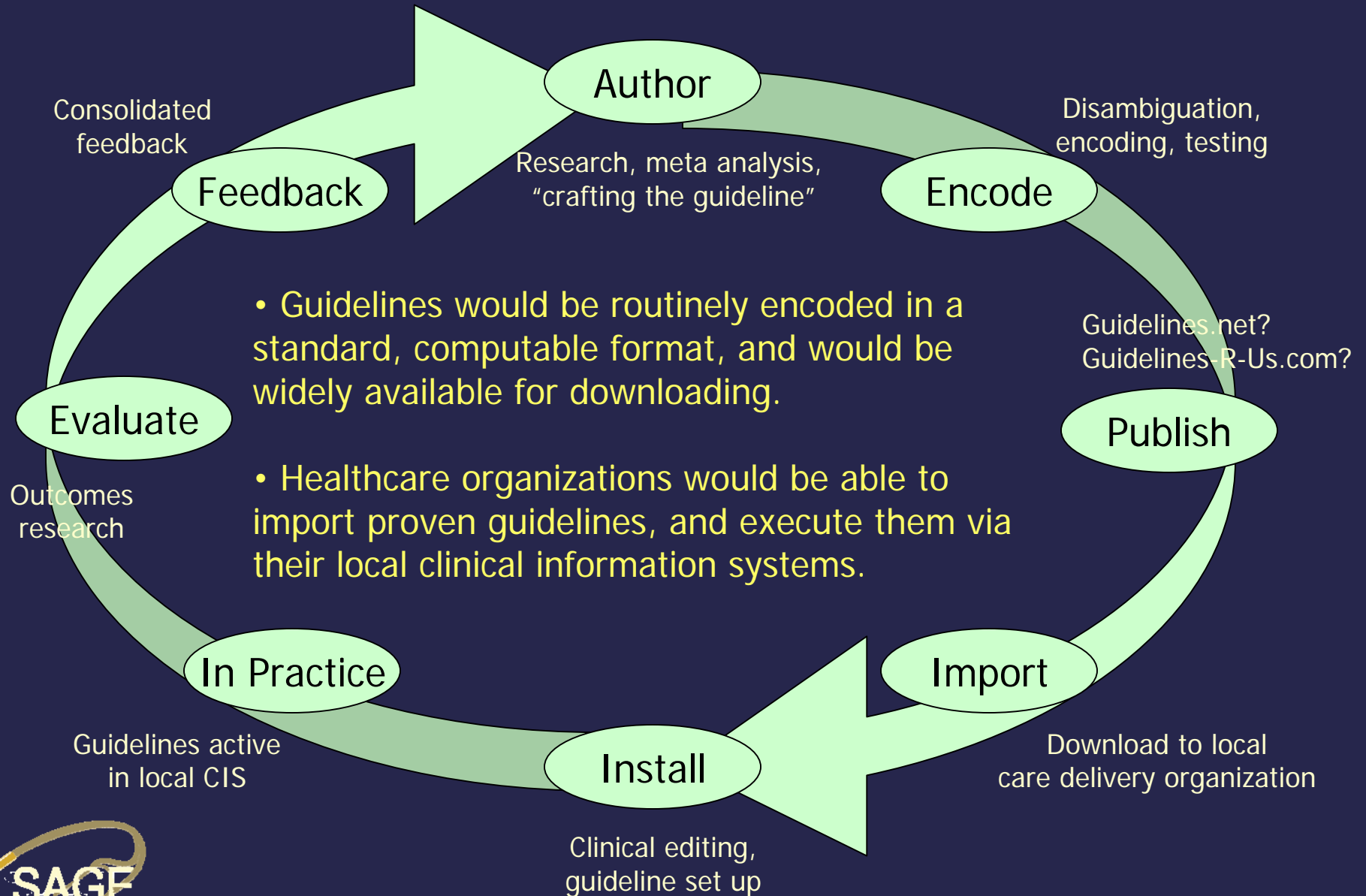
robert_abarbanel@idx.com

Easy fluffy stuff:

guy_mansfield@idx.com

Spare Slides

The SAGE Guideline Lifecycle



SAGE Interoperability Goals

- In common terms, interoperability is “plug-and-play” functionality, in this case – for clinical knowledge and decision support
- Requires that the software employs the same terminology, models knowledge using the same constructs, and is applied only in comparable clinical environments
- Allows different institutions to share software and knowledge bases
- Required if we want to achieve economies of scale in clinical decision support: “*Write once, use many*”



SAGE Exemplar Guidelines

Guideline	Clinical Domain
Immunizations	Routine health maintenance, in both outpatient and inpatient settings.
Diabetes Management	Chronic disease monitoring and treatment. Acute exacerbation of chronic disease. Chronic disease as a comorbidity.
Community Acquired Pneumonia	Emergency room evaluation and diagnosis. Outpatient treatment of acute disease. Inpatient and ICU treatment of acute disease. Follow-up of acute disease.
Total Joint Replacement	Surgical guideline. Comprehensive pre-op workup, inpatient plan of care, and post-op outpatient management.

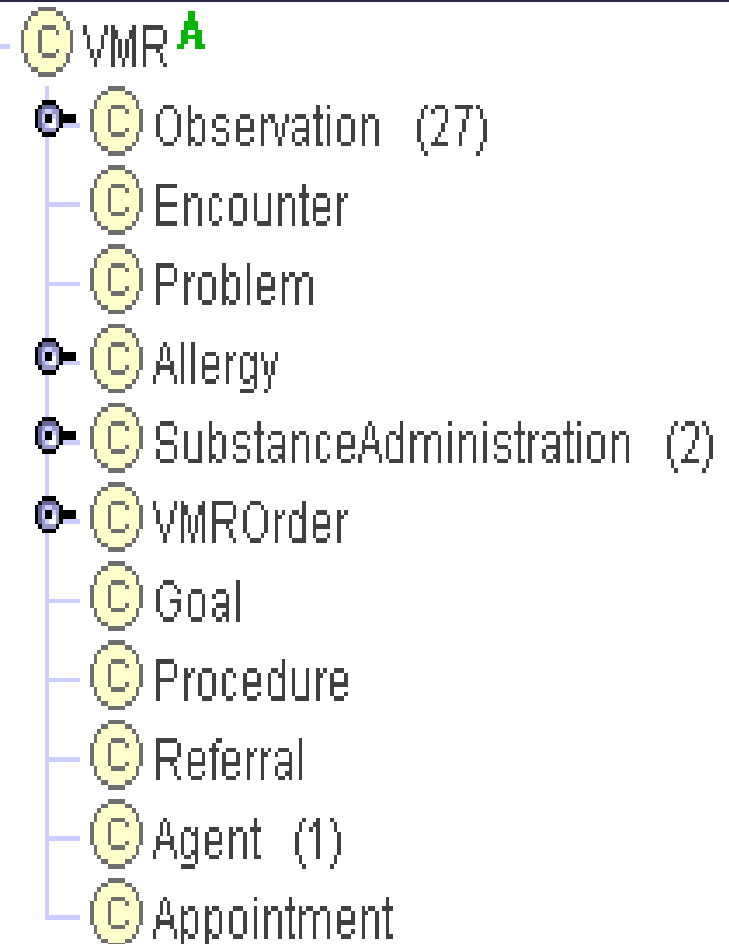


State Management and Triggering Events

- A guideline execution session is triggered by detection of context-specific events.
- Execution begins at a Context Node, and (in general) continues until the next Context Node is reached.
- Multiple activity graphs can execute simultaneously, resulting in multiple threads for multiple patients at any given time.
- Guideline execution is “stateless” (with some exceptions).

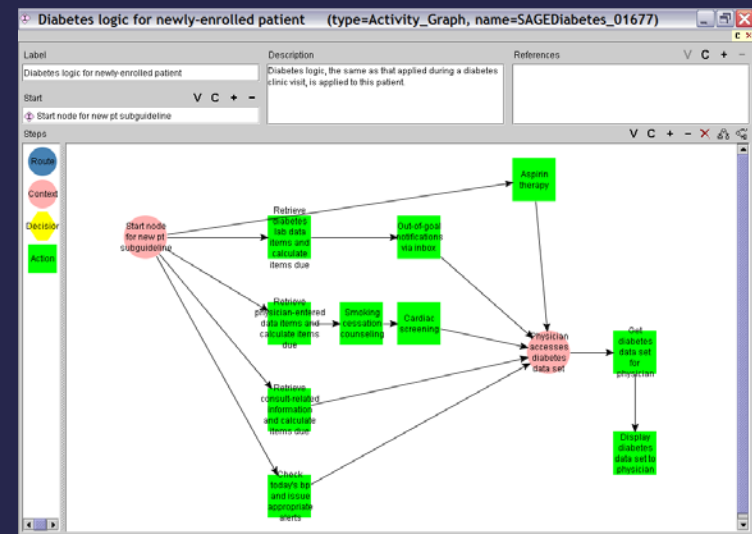
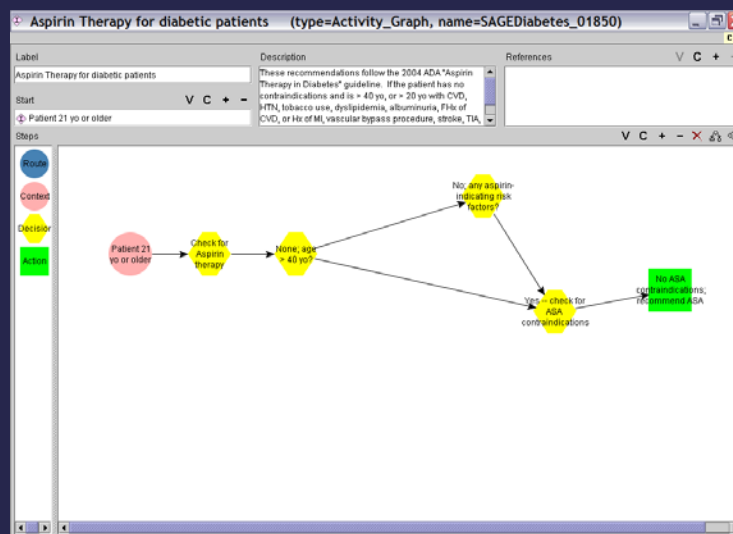
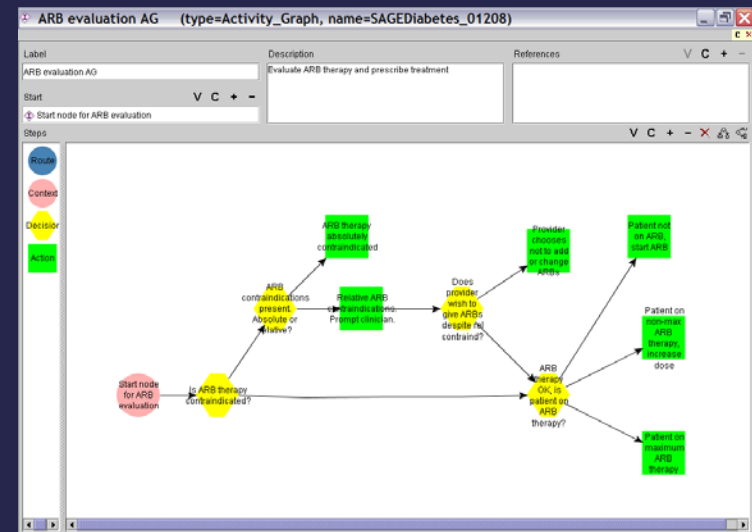
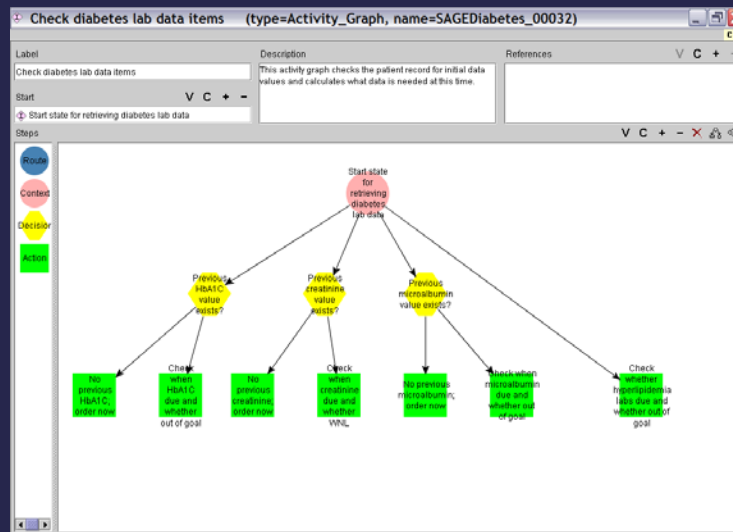
vMR // Webservices

- Protégé classes “**define**” web-services through which SAGE communicates with the CIS
- Attributes of these vMR classes control the ways requests are modeled in the guideline and, thus, the way that calls to the CIS are composed.

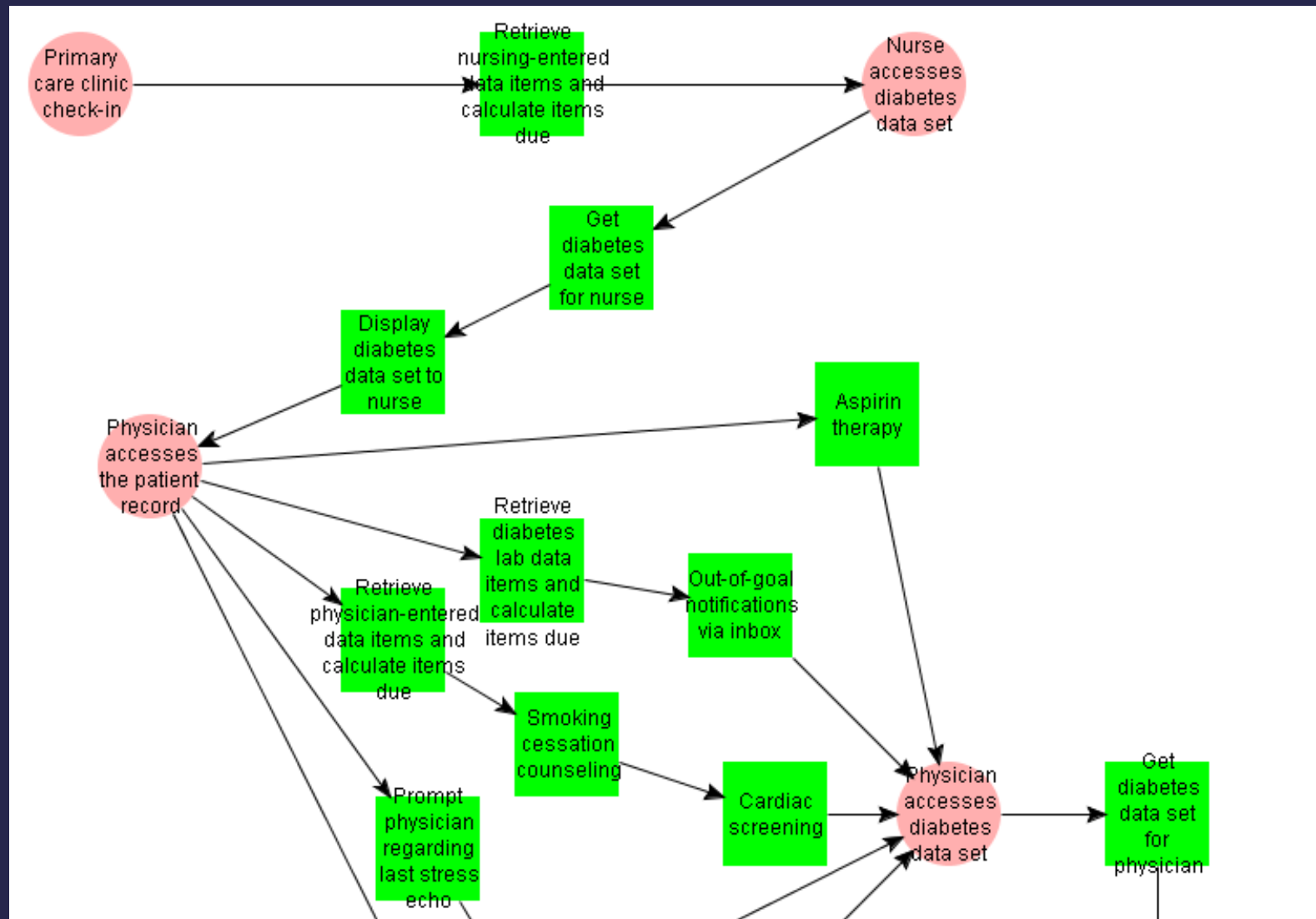


Guideline Knowledge Representation

Objective: A standards-based representation of arbitrarily complex clinical practice guidelines in a computable format.



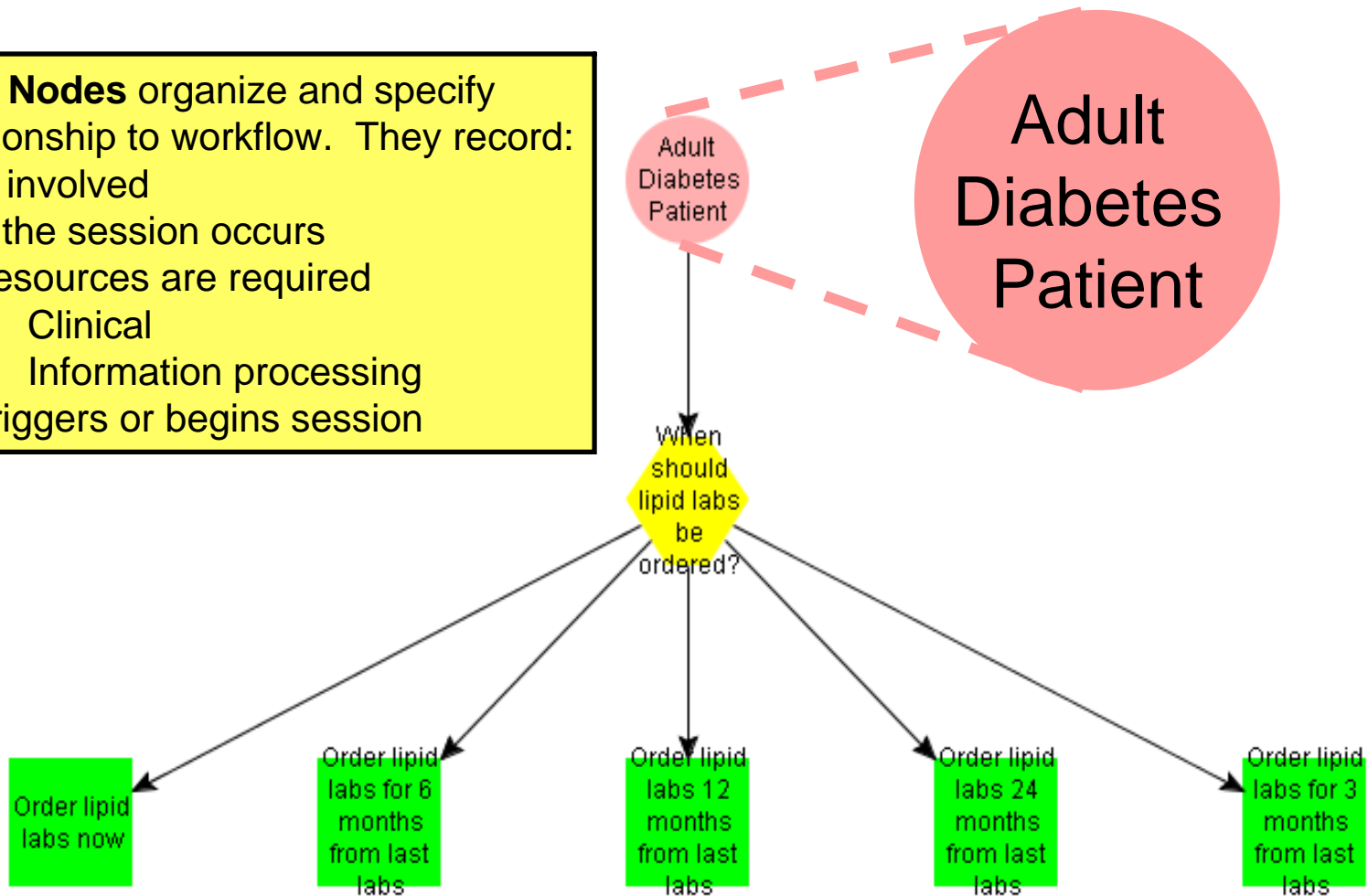
Sample Activity Graph: Diabetes Primary Care



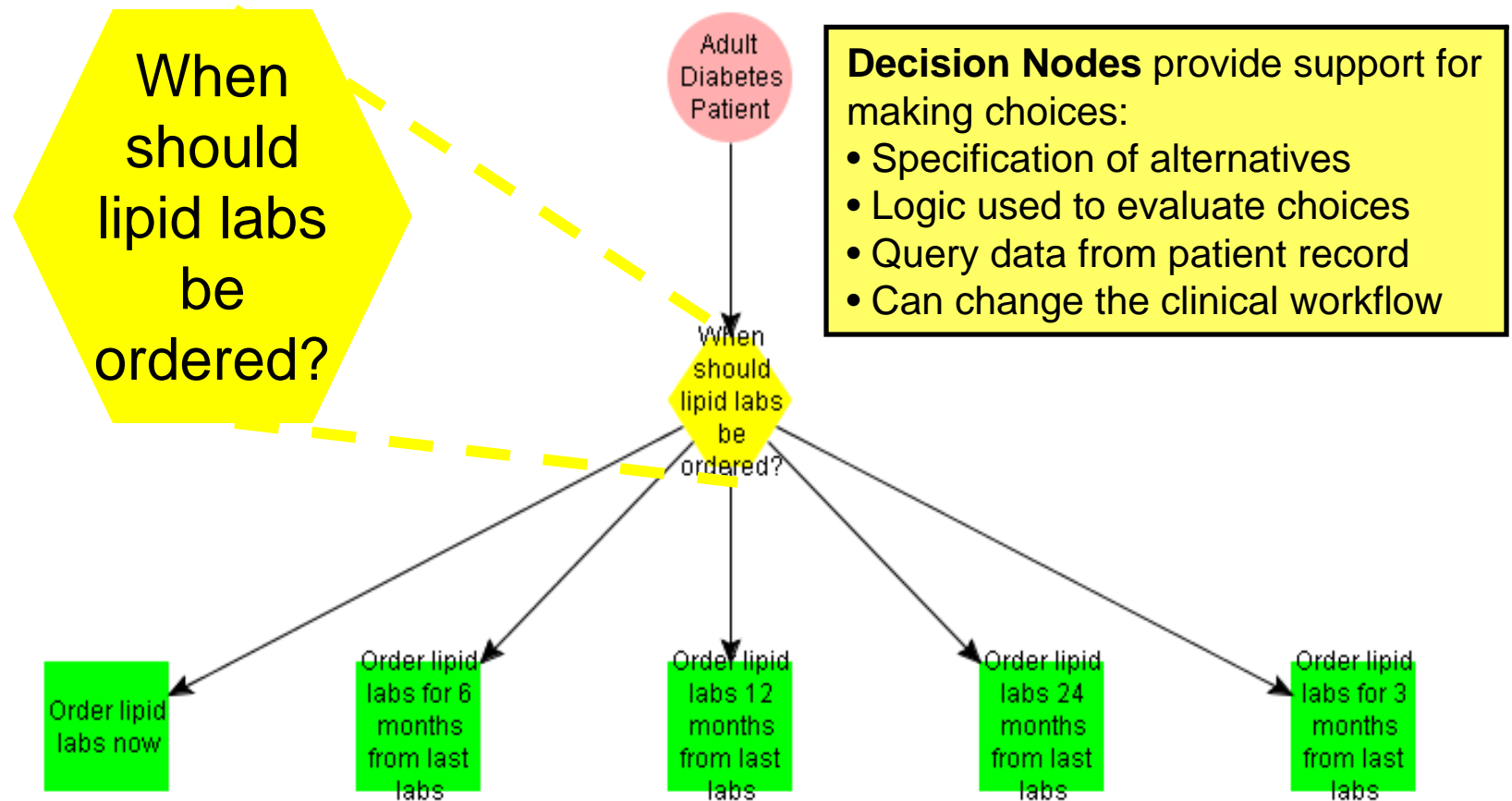
SAGE Guideline Representation: Context Nodes

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

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



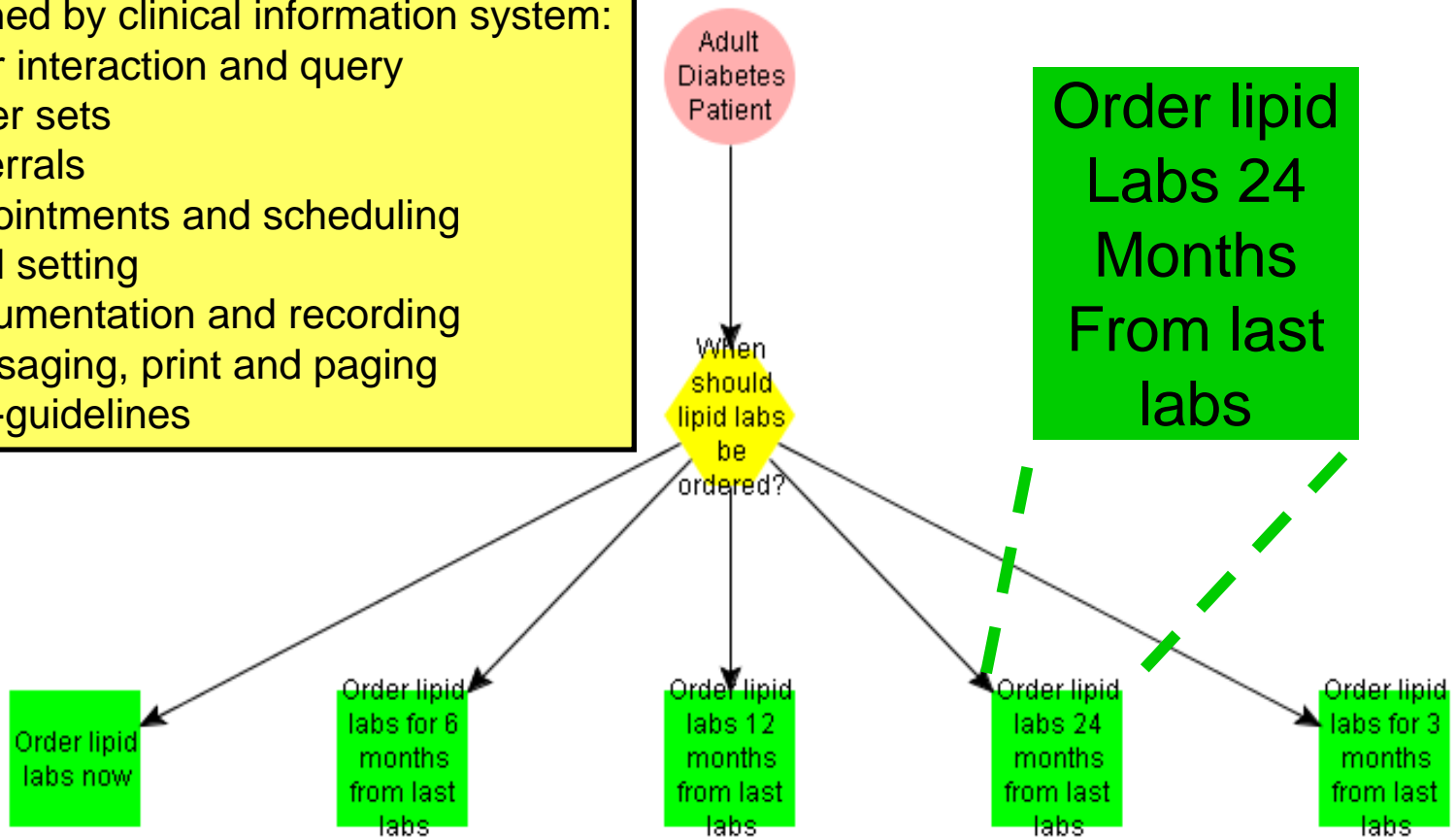
SAGE Guideline Representation: Decision Nodes



SAGE Guideline Representation: Action Nodes

Action Nodes define activity to be accomplished by clinical information system:

- User interaction and query
- Order sets
- Referrals
- Appointments and scheduling
- Goal setting
- Documentation and recording
- Messaging, print and paging
- Sub-guidelines

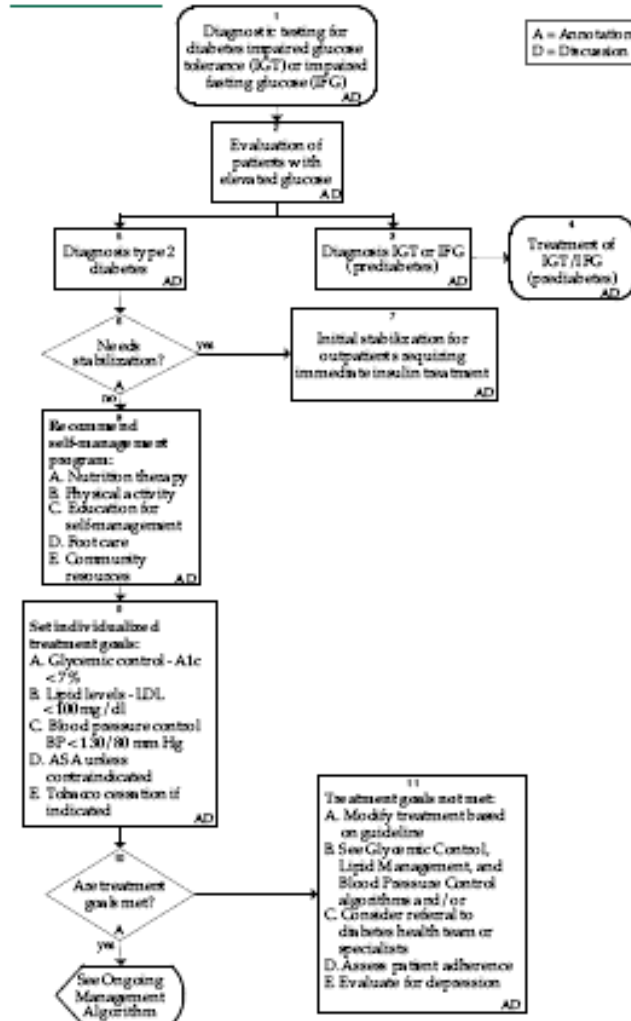


Guideline Knowledge Encoding and Representation

- Start with source guideline (text)
- Encode guideline content aimed at specific clinical care scenarios
- Envision clinical workflow and identify opportunities for decision support
- Determine how guideline recommendations can best be presented via CIS functions



Health Care Guideline: Management of Type 2 Diabetes Mellitus



General Implementation September 2002

Work Group Members
Work Group Leader
 JoAnn Sperk-Hill, MD
Health/Behavior Medical Group
Endocrinology
 Richard Bergental, MD
Health/Behavior Medical Group
 Steve Smith, MD
Mayo Clinic
Nephrology
 Michael G. Sommers, MD
Kidney Disease and Critical Care Association
Family Practice
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Internal Medicine
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Podiatry
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Pharmacy
 Peg Sarna, RPh
Health/Behavior Medical Group
Medical Nutrition Therapy
 Cindy Hultstrom, RD, CDE
Health/Behavior Medical Group
Nursing
 Bev Walsh, RN, CDE
CentralCare Health System
Health Education
 Cindy Hultstrom, RD, CDE
Health/Behavior
Measurement Advisor
 Jane Gordon
ICS
Facilitator
 Jennie Meyer, RN
ICS

These clinical guidelines are designed to assist clinicians by providing an analytical framework for the evaluation of treatment options, and are intended to be used to replace a clinician's judgment or to establish a protocol for all patients with a particular condition. A guideline will not establish the only approach to a problem.

www.icsi.org

Courtesy: Institute for Clinical Systems Improvement

