



"A collaborative project to
develop a universal framework for
encoding and disseminating electronic clinical guidelines"

The SAGE Project

Standards-Based Sharable Active Guideline Environment



II. Illustration of SAGE Technology



"A collaborative project to
develop a universal framework for
encoding and disseminating electronic clinical guidelines"

The SAGE Project

Standards-Based Sharable Active Guideline Environment

Guideline Execution

The Immunization Guideline

12 November 2003



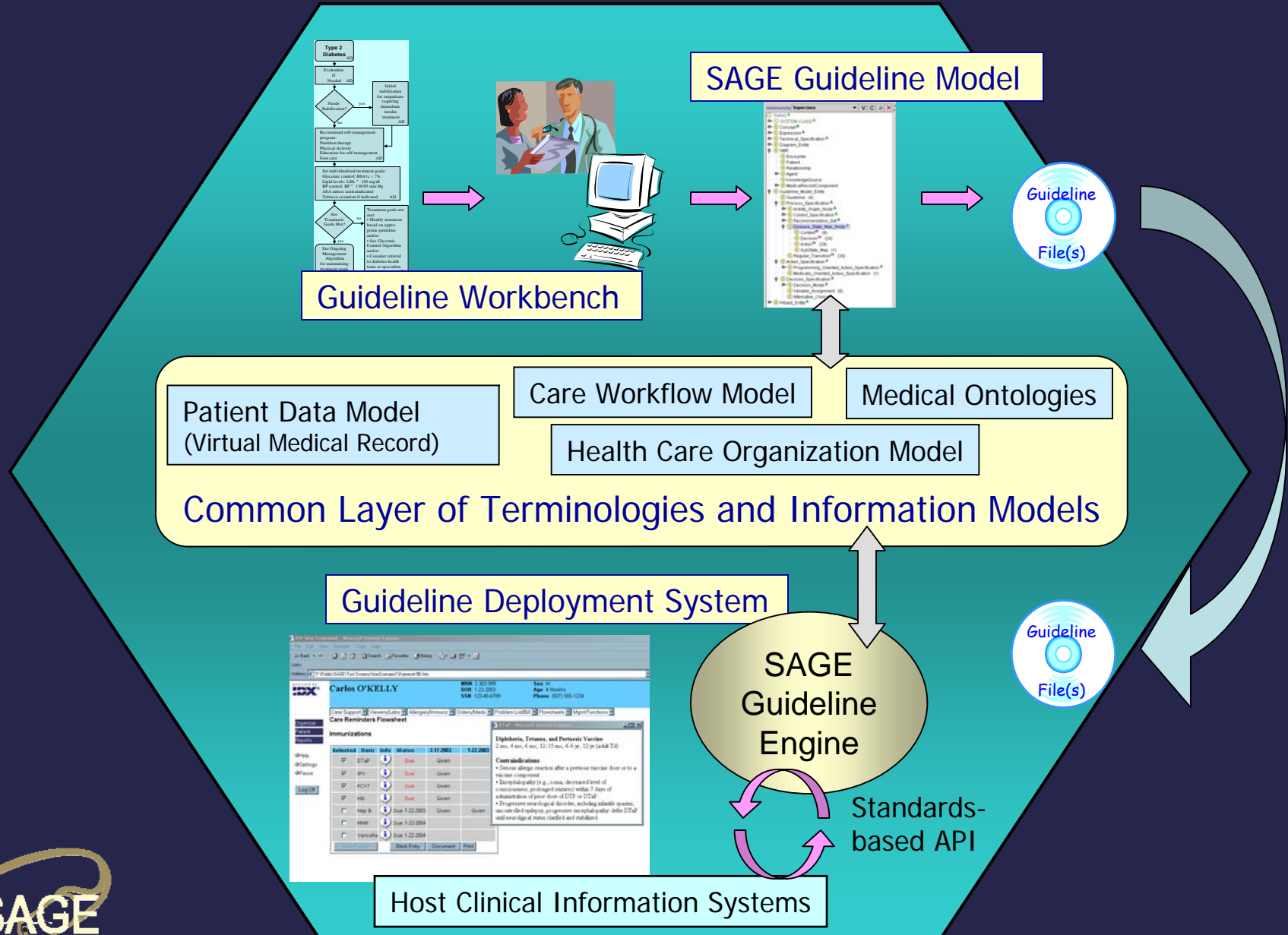
SAGE Exemplar Guidelines

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 cormorbidity.
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.

SAGE Execution

- Architecture
- Semantics of the guideline model
- Event driven interpretation
- Evaluation of criteria
- Example of decision making
- SAGE Actions

Overview of the SAGE Infrastructure





What's on the SAGE CD ?

Guideline Metadata	Information about the encoded guideline: Version, source, authors, dates, etc.	Included in Protégé KB
Guideline Logic	The encoded clinical and operational logic of the clinical practice guideline. This includes pointers to references and source data as appropriate	Included in Protégé KB
Execution Semantics	The additional information needed to procedurally execute the Guideline Logic KB	tbd
Clinician readable logic	The guideline logic in a narrative format that is readable Guideline logic and understandable by practicing clinicians	XML, XSLT
Test data	Specification (or set) of test data that can be used to validate guideline logic	XML
Installation data and scripts	Specification of the "system" requirements (HIS/CIS). Specifications, resources/capabilities required to run this executable guideline	Text, programs

SAGE Deployment Components

Guideline

S
A
G
E

VMR Services	B i n d i n g
CIS Actions	
SAGE Notif-ications	

C
I
S



SAGE Deployment Components

Guideline

S
A
G
E

VMR
Services

CIS
Actions

SAGE
Notif-
ications

B
i
n
d
i
n
g

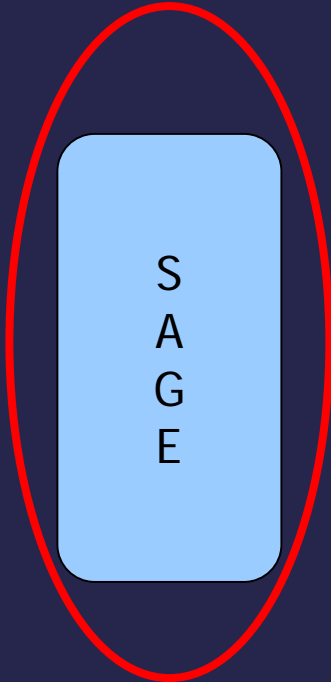
C
I
S

Authored in Protégé
Localized using Protégé
Guideline described using standard
VMR classes,
CIS Actions
Standard Terminology

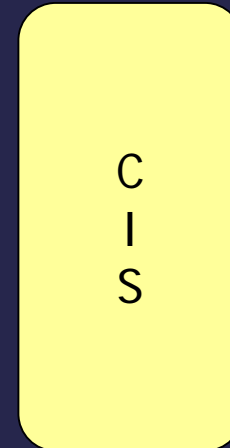


SAGE Deployment Components

Guideline



VMR Services	B i n d i n g
CIS Actions	
SAGE Notif-ications	



Executes the guideline

SAGE Deployment Components

Guideline

S
A
G
E

VMR
Services

CIS
Actions

SAGE
Notif-
ications

B
i
n
d
i
n
g

C
I
S

SAGE facing side stays the same
CIS facing side changes per CIS

Includes mapping methods from
standards to local CIS
functions/concepts

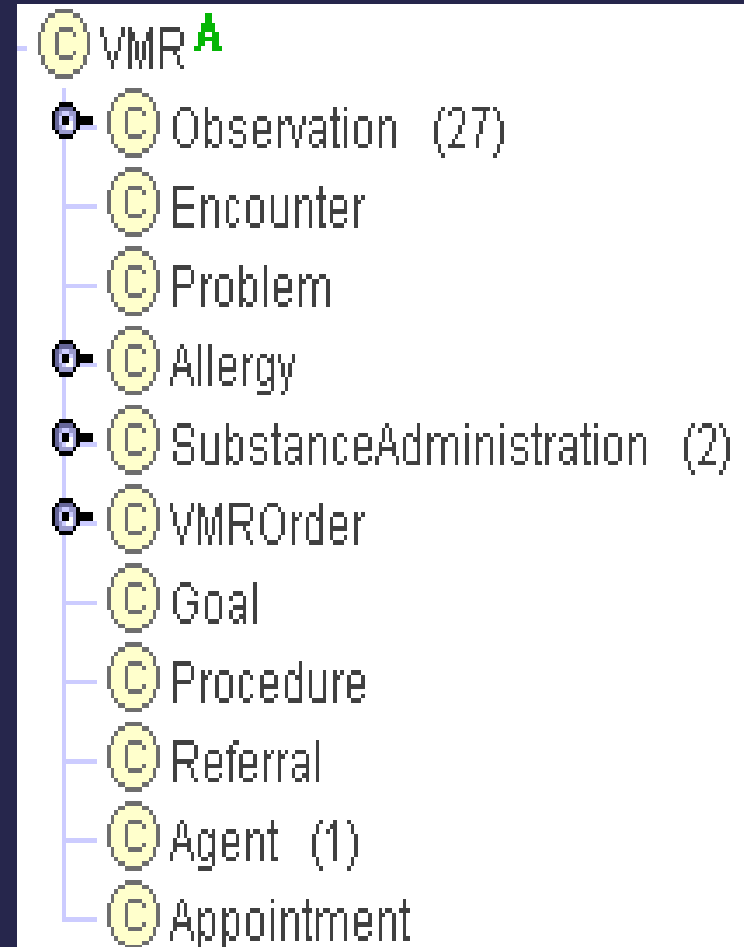
Includes concept mapping

Listens on events being sent by CIS



vMR // Webservices

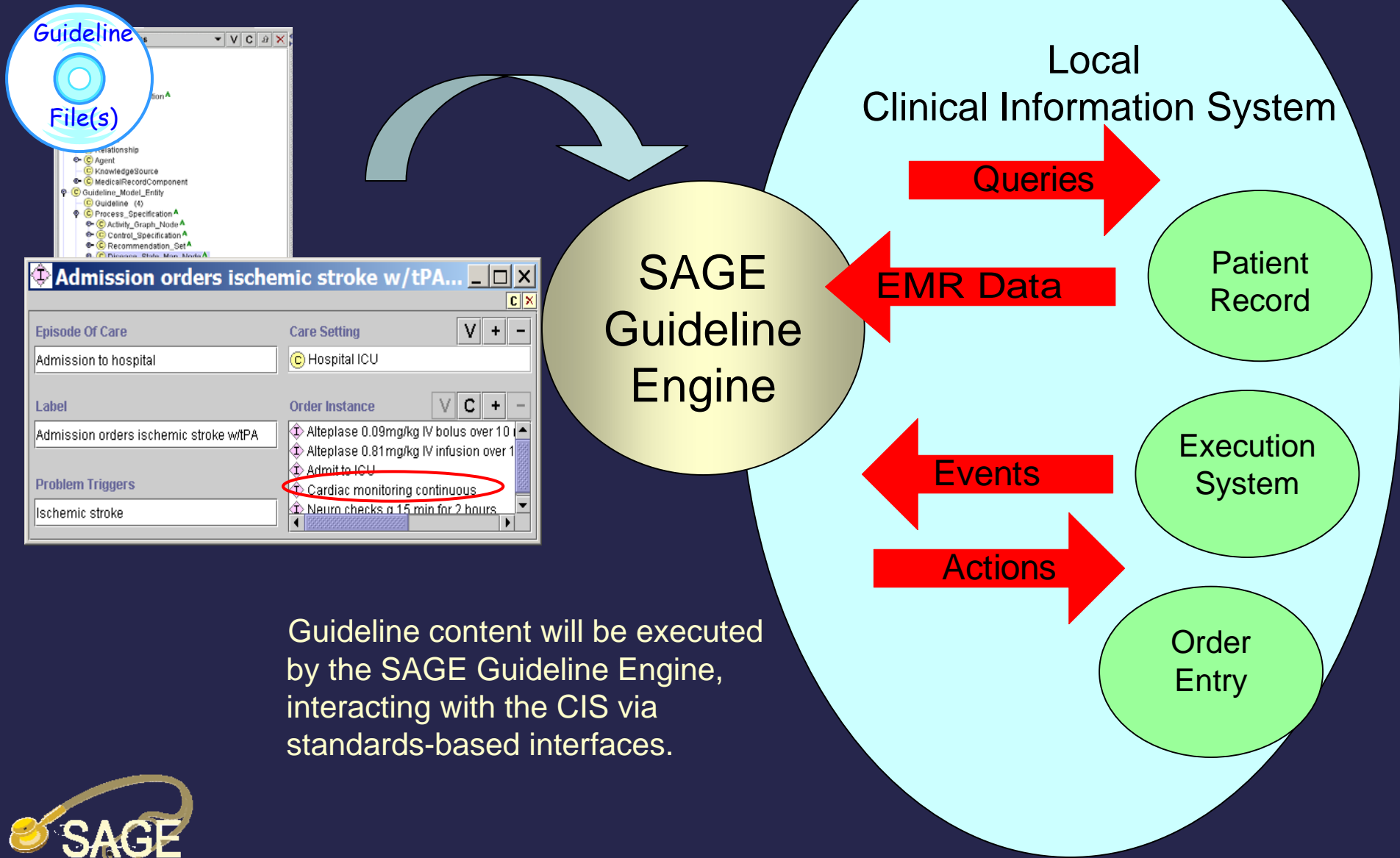
- Protégé classes “**define**” web-services through which SAGE communicates with the CIS
- Attributes of these vMR classes control the ways requests are modeled in the guideline and, thus, the way that calls to the CIS are composed.



vMR functions

- getDemographics
- getProblemList
- getProblem
- getProblemTemporal
- getProblemPresence
- getAllergyPresence
- getAllergyList
- getAllergy
- **getObservationTemporal**
- getObservationValue
- getObservationPresence
- getObservationCount
- getFinding
- getFindingPresent
- getFindingCount
- getSubstanceAdminPresence
- getSubstanceAdminCount
- getSubstanceAdminTemporal

SAGE Guideline Execution: Deployment Concepts

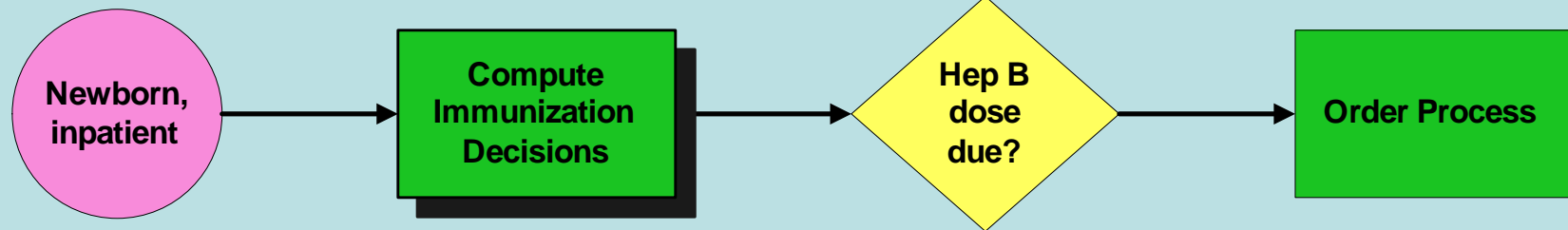


Guideline content will be executed by the SAGE Guideline Engine, interacting with the CIS via standards-based interfaces.

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A Recommendation Set for Neonatal immunization orders...



A Recommendation Set for Neonatal immunization orders...

Newborn,
inpatient

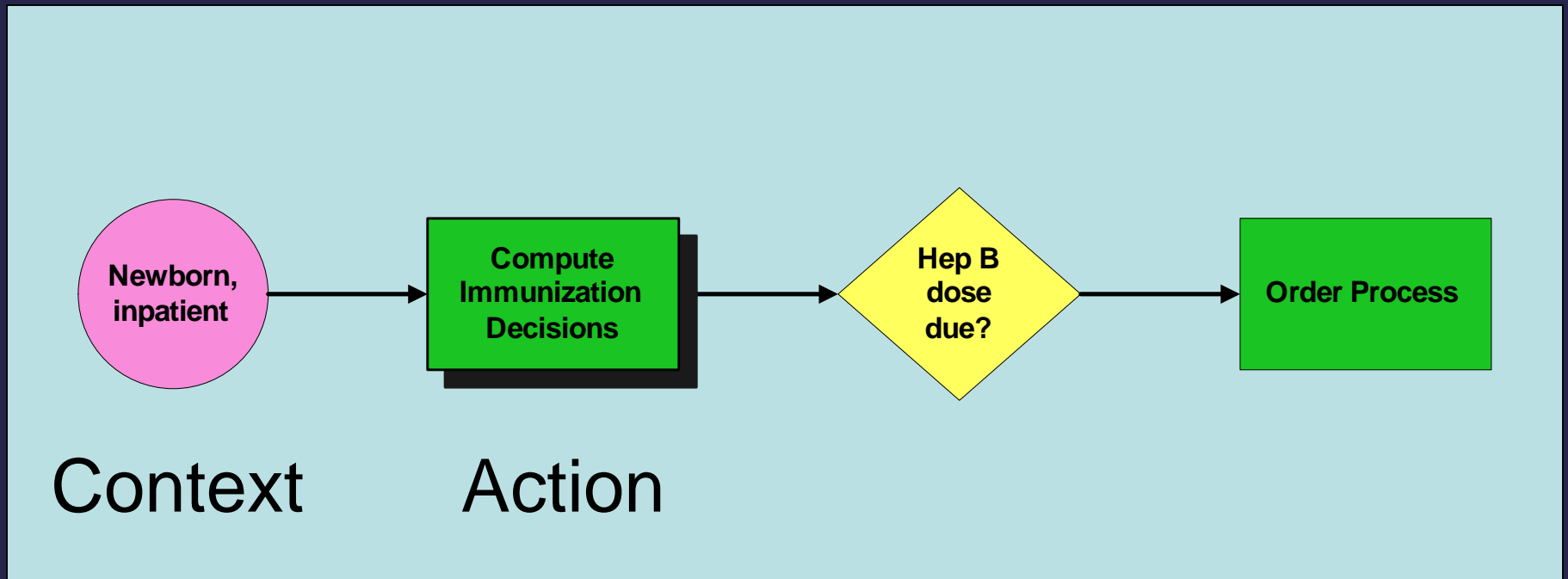
Compute
Immunization
Decisions

Hep B
dose
due?

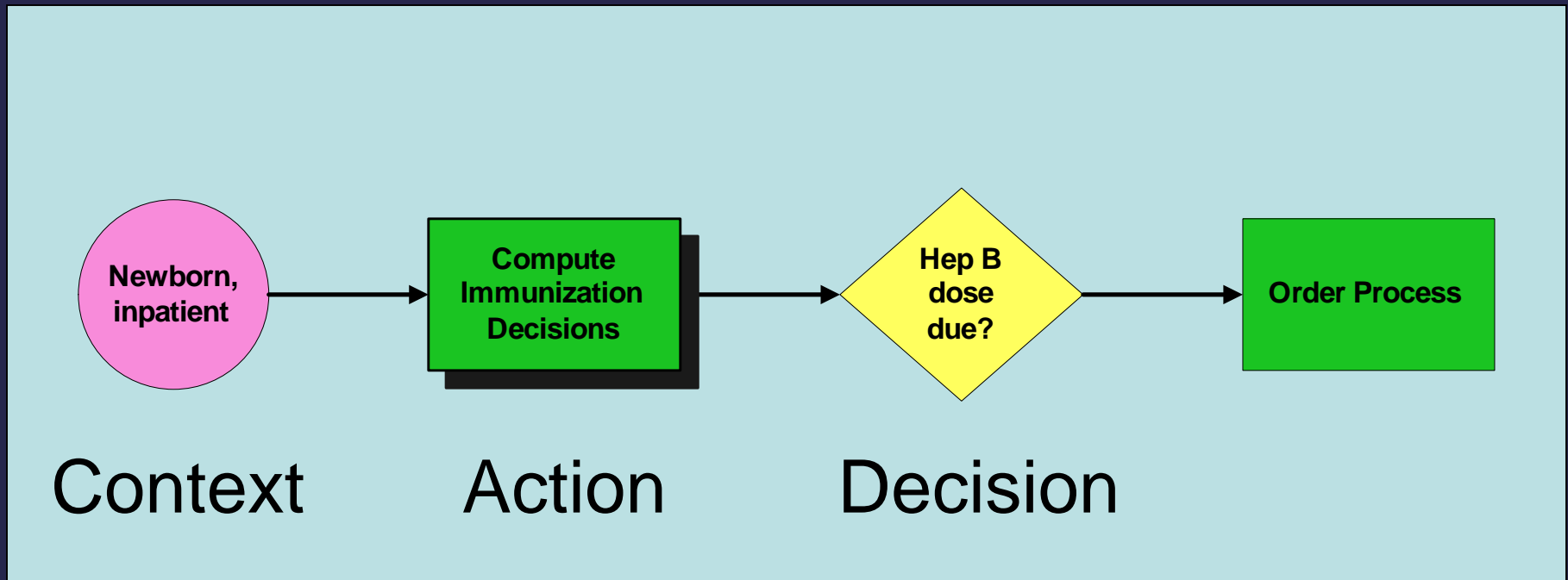
Order Process

Context

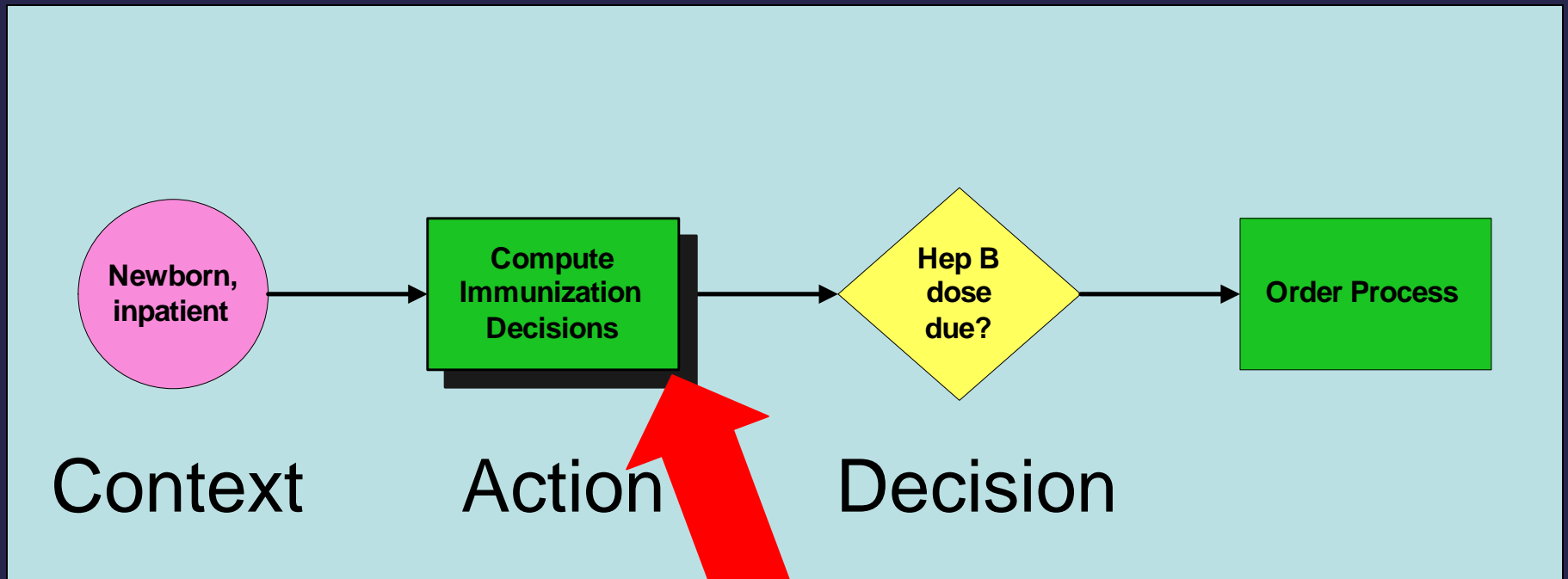
A Recommendation Set for Neonatal immunization orders...

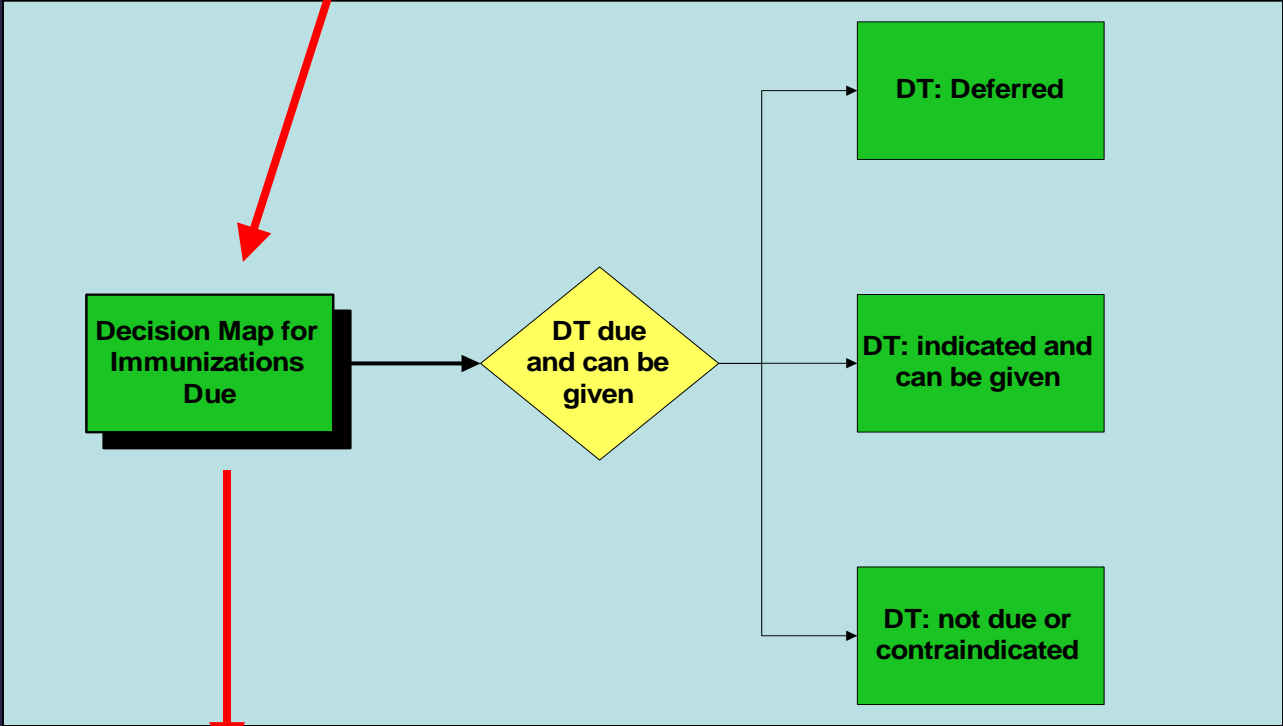
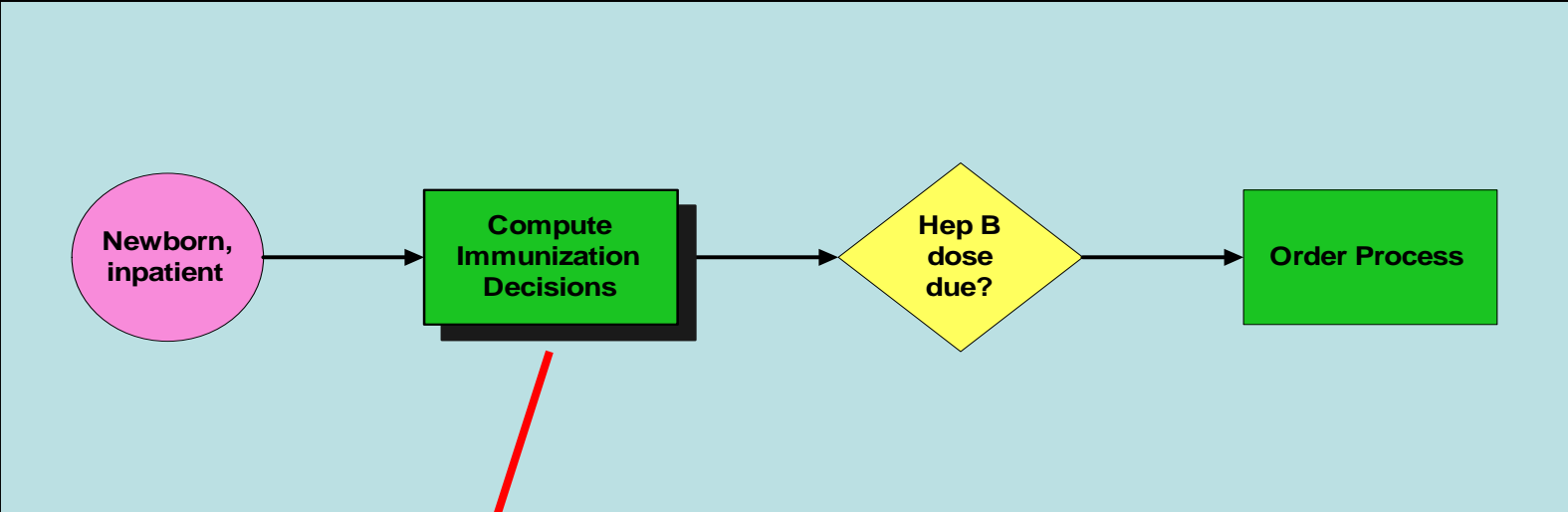


A Recommendation Set for Neonatal immunization orders...

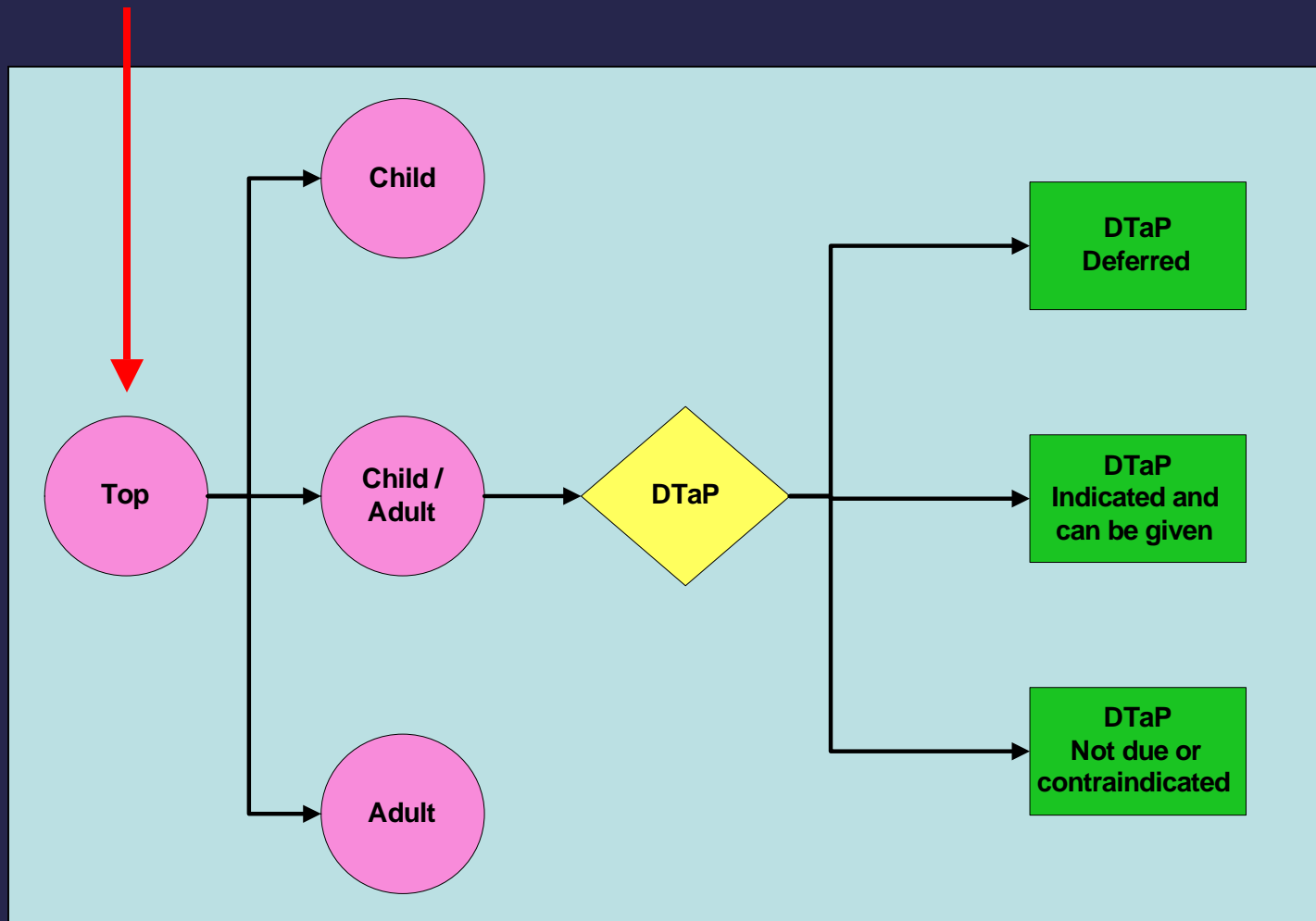


A Recommendation Set for Neonatal immunization orders...





Immunization Decisions: DTaP



Guideline Scenario: Neonatal Orders for Immunization

Baby Boy Jones is a newborn admitted to the neonatal nursery. Triggered by this admission, guideline decision logic evaluates the infant's birth date/time, weight, immunization history/status, and the mother's hepatitis B serologic status:

If patient age < 7 days AND weight is over 2 kg AND mother's hepatitis status is positive, a communication will be sent to the nurse to check for immunization contraindications, review immunization history, and obtain vaccination consent.

After speaking with the mother, the nurse uses the CIS to update the patient's record. These updates might include the mother's hepatitis B serology status, infants weight, and presence of contraindications. These updates to the patient's EMR trigger a second round of decision logic that then recommends appropriate immunizations.

Guideline-recommended immunizations are instantiated in the CIS as orders (or ordersets) that can be approved, processed, charted, etc. via normal CIS patient care functions.



Baby Boy Jones

- ✓ 2229 gram
- ✓ 34 week gestation neonate
- ✓ delivered by emergency C-section due to placental abruption
- ✓ His 20 year old mother received no prenatal care.
- ✓ Mother's urine drug screen was positive for methamphetamines.
- ✓ Mother's HBsAg serology was positive.
- ✓ Problem listed: "newborn exposure to Hepatitis B"



Baby Boy Jones

Expected SAGE Behavior (4 orders):

- **2 Substance administrations**
due immediately
 - Hepatitis B vaccine injection
 - Hepatitis B Immune Globulin (HBIG)
- **2 Serologic tests**
due 9 months in the future
 - Hepatitis B core antibody levels (anti-HBc)
 - Hepatitis B surface antigen levels (HBsAg)

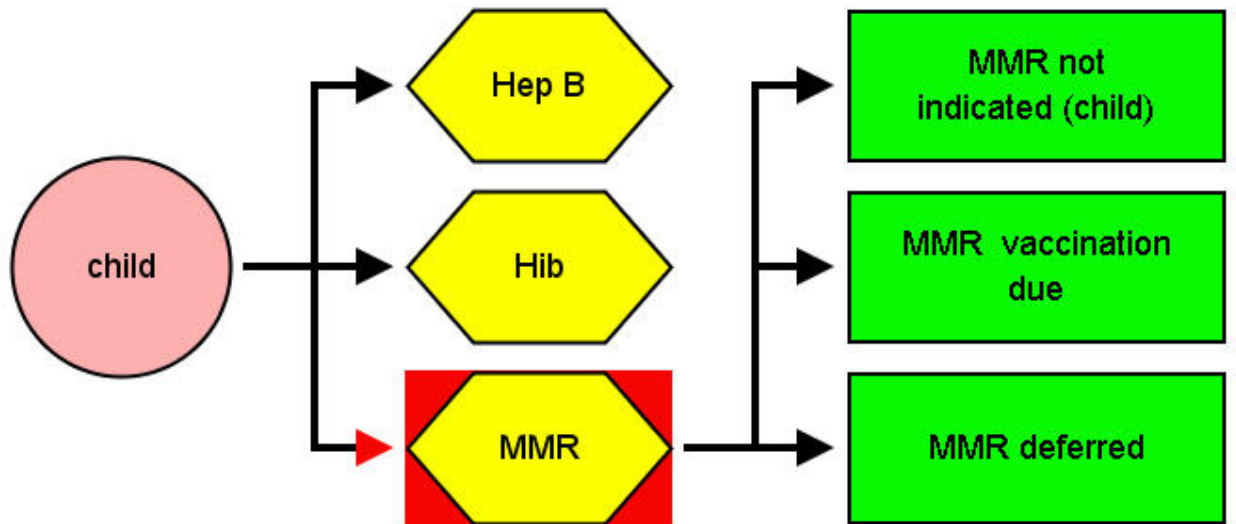
SAGE Guideline Execution:

```
SAGE - Log Monitor: server.log
| criterion: Polio vaccine indicated re
| criterion: Polio vaccine not indicate
| decision: Polio vaccination due and can be g
| criterion: DTaP immunization due resu
| action sp: retract Td due conclusion
| action sp: retract Td vaccine to be d
| action: Td vaccination not due or contraind
| action sp: retract varicella due pid=
| action sp: retract varicella vaccine
| action: Varicella vaccination not due or con
| action sp: C
| action: Hep B immun
```

Log

Compute Immunizations / Decision Map

Monitor



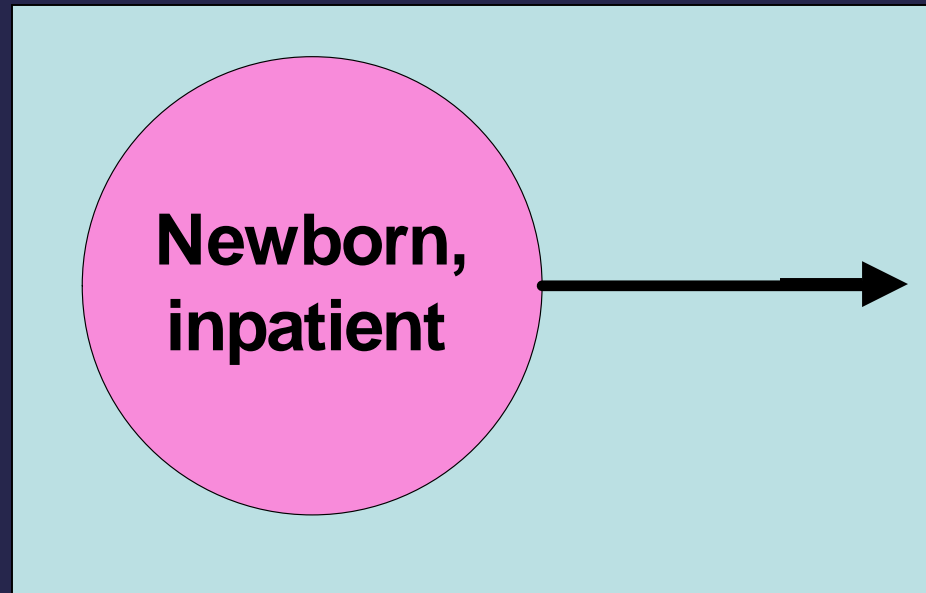
SAGE Execution

- Architecture
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Neonate w/ HepB positive mother

Triggering event

SAGE engine detects admission event.



Reg Screen w/ DOB

01005842 JONES, Baby boy - M

File Patient Session Navigate Help

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

Change Patient Demographics (1 of 2)

<p>Patient Name</p> <p>Last Name: JONES</p> <p>First Name: Baby boy MI:</p> <p>Birth Name:</p> <p><input type="checkbox"/> Registration Update Alias?</p>	<p>Demographic</p> <p>Sex: M DOB: 24Aug2003</p> <p>Race: 1 Marital:</p> <p>Religion: Cong:</p> <p>Soc Sec #:</p> <p>Handicap? Interpreter?</p>	<p>Care Provider</p> <p>Reg Care Fac: LWGH <input type="checkbox"/> New Prov?</p> <p>Reg Provider: ATTENDING, RAY 755000</p> <p>Specialty Prov:</p> <p>Specialty Prov:</p> <p>Referral Agency:</p> <p>Unregistered Referral</p> <p>Last Name:</p> <p>First Name: MI:</p>
<p>Mailing Address</p> <p>Street:</p> <p>City: SEATTLE</p> <p>State: WA Zip: 98104</p> <p>County:</p> <p>Night Phone:</p> <p>Day Phone:</p> <p>IP: OP:C</p> <p>Alternate ID #:</p> <p>Alternate ID2 #:</p>	<p>Employer</p> <p>Emp Code: Status:</p> <p>Employer:</p> <p>Street:</p> <p>City:</p> <p>State: Zip:</p> <p>Phone:</p> <p>Occupation:</p> <p>Emp ID #:</p>	<p>Flags</p> <p>Registration: UR: (Flag4):</p> <p>Financial: Local10Only HMA Excl:</p> <p>Debt: (Flag2): Adv Dir:</p> <p>Legal: (Flag3): PLS: 1</p> <p>Reg Flags To ADT</p> <p>DNA? VIP: (Flag5a):</p> <p>IFD: (Flag4a): (Flag6a):</p>

Save Data and Continue

CREG1 | 14Aug2003 Thu | 4D | 252-ADF1 | 0.3 | LWGH



MD Screen for Jones with No Inbox entries

The screenshot shows a medical software interface with the following components:

- Desktop:** A table listing patients. The selected patient is JONES, Baby boy (MRN 01005842).
- Patient List Directory:** A table listing lists. The selected list is Sage Testing.
- Inbox Messages:** A section with a table for notifications, which is currently empty. A red arrow points to this section.
- Command Central:** A section for entering commands, with the active MRN set to 01005842.

MRN	Patient Name	Other Information
01005800	ANDERSON, Paige	
01005867	CHAPMAN, Lucy	
01005776	HORNER, Jack	
01005842	JONES, Baby boy	LWGH A401 Attending, Ray
01005784	MCCRAY, Jim	
01005834	SMITH, Suzy	
01005875	STOCK, Marie	
01005883	THOMAS, John	
01005826	TUCKER, Tommy	
01005792	WHITE, Tristan	

List Name	Type	Owner
Hotlist		
CAR Service	CHSS	
Sage Testing	PERS	Attending,
TemporaryList	PERS	Attending,

Notifications	Count

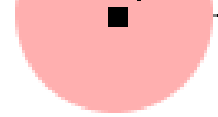
Command Central: Command: [] Active MRN: 01005842 Global Name Lookup

System Information: .LSTMD | 14Aug2003 Thu | 4D | 252-ADF1 | 2.2 | LWGH



Triggering Event: CIS Admission from ADT System

new-born
in hospital



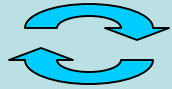
Triggering Events

© Inpatient hospital admission event

Precondition

◇ age < 7 days

SAGE Event Mechanism



Normal CC
Processing

CIS



New CC
app
SAGE
Listener
(Cobol/Java)

Web Service

SAGE

Inpatient
Newborn

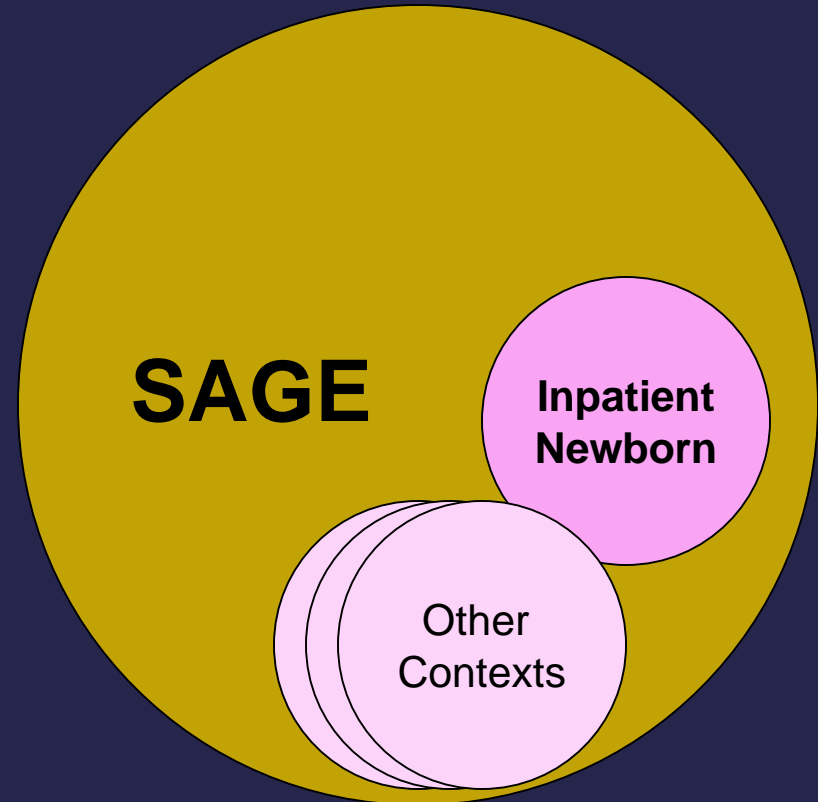
Other
Contexts



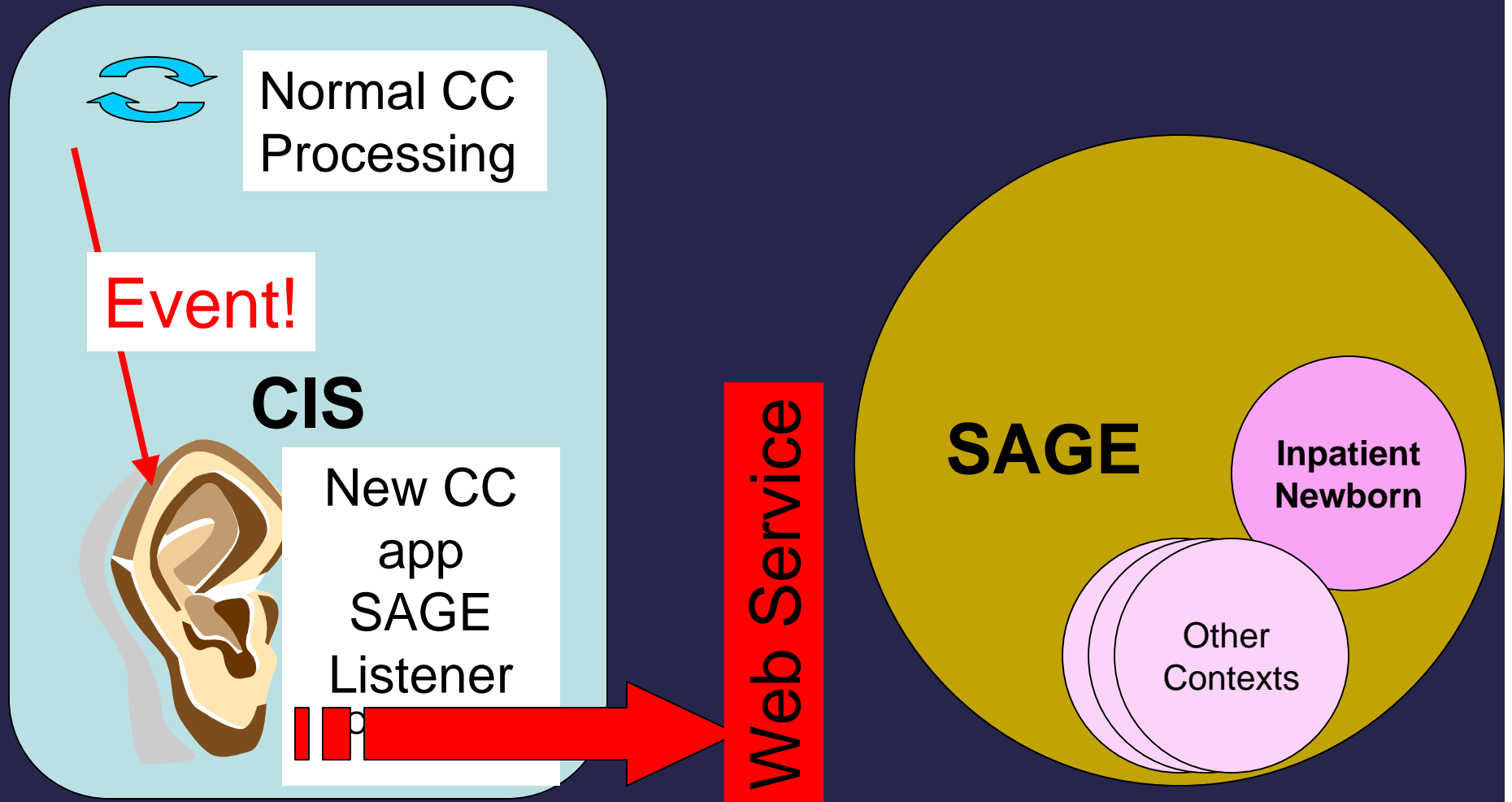
SAGE Event Mechanism



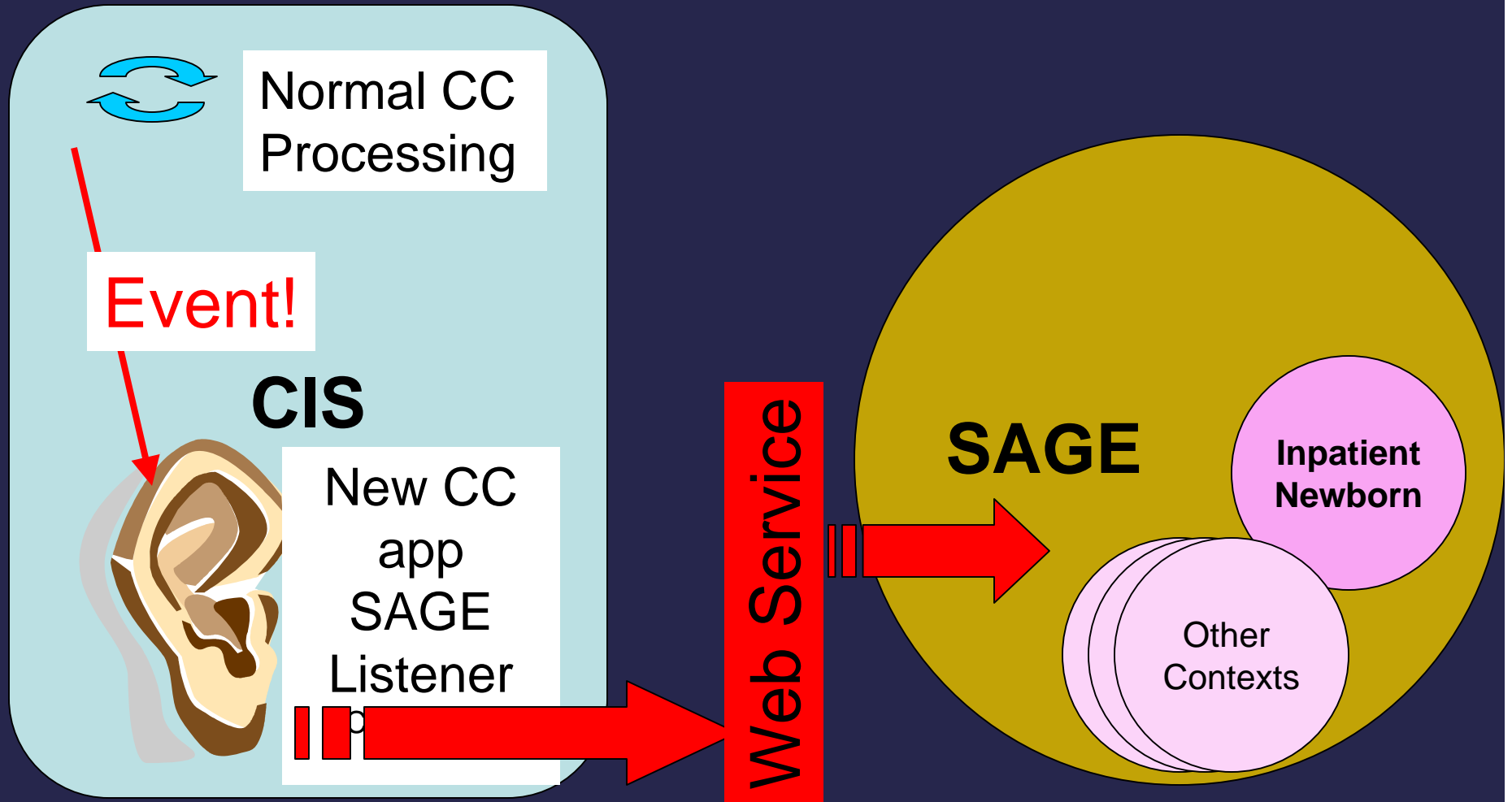
Web Service



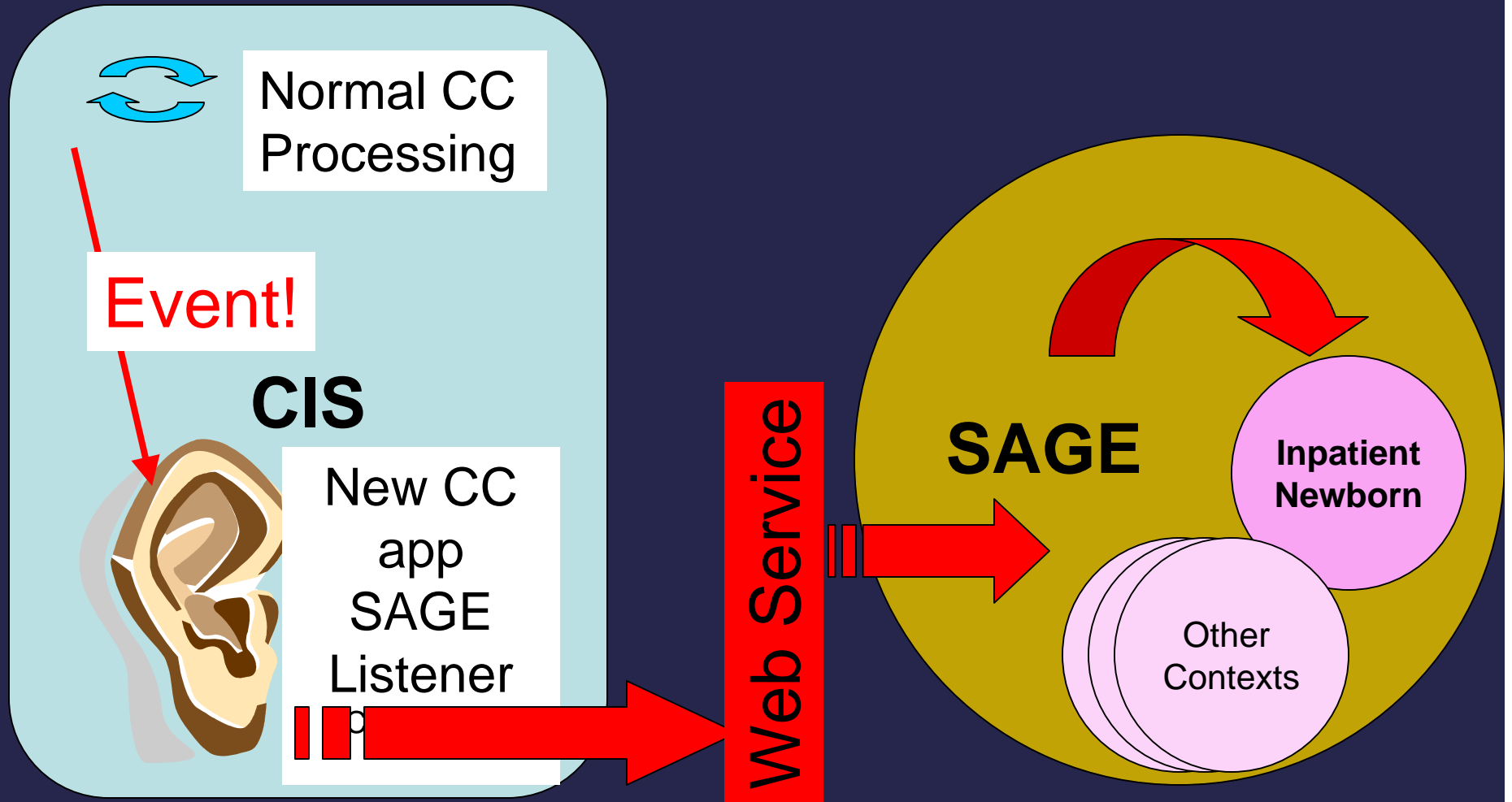
SAGE Event Mechanism



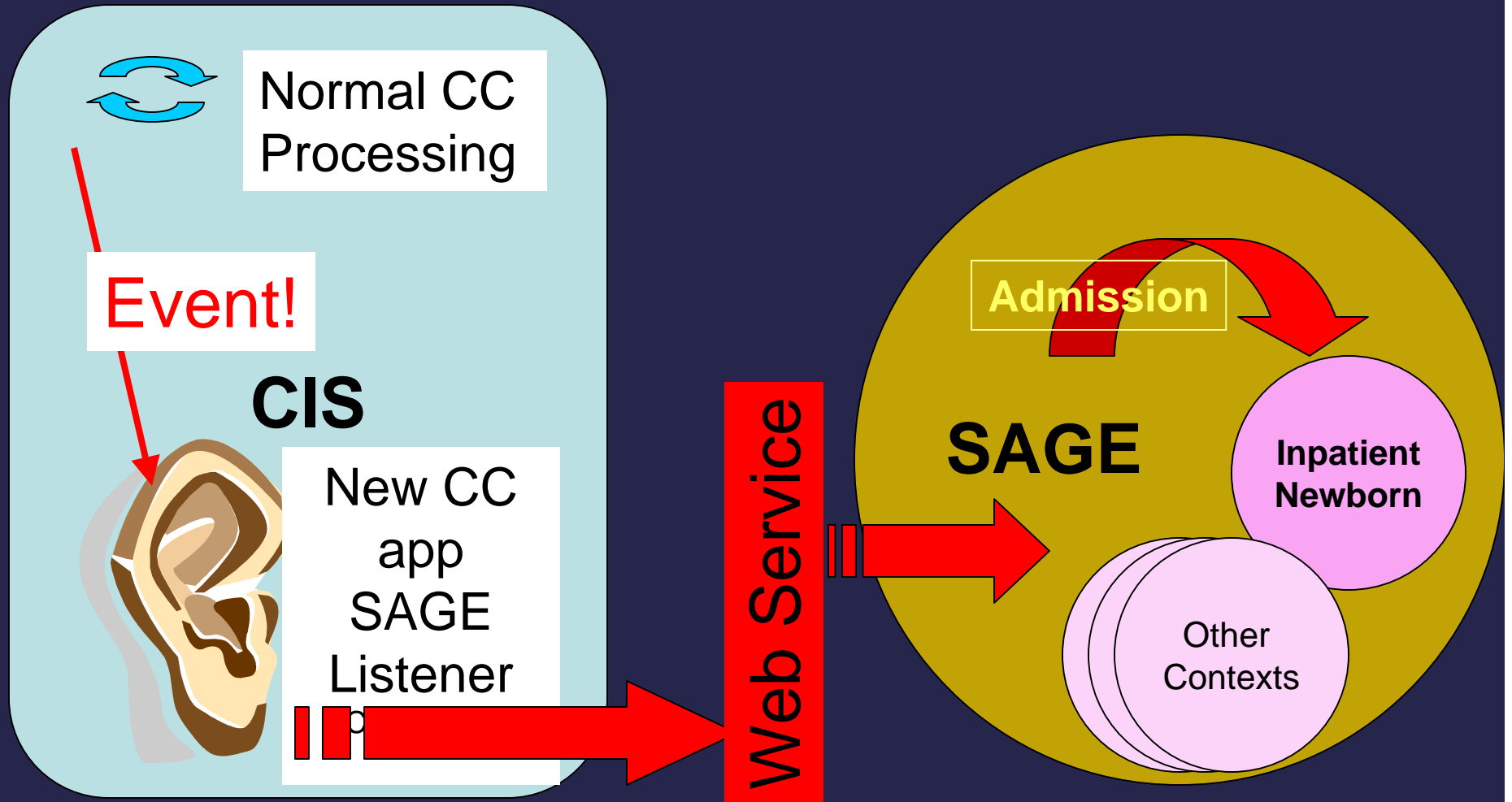
SAGE Event Mechanism



SAGE Event Mechanism



SAGE Event Mechanism



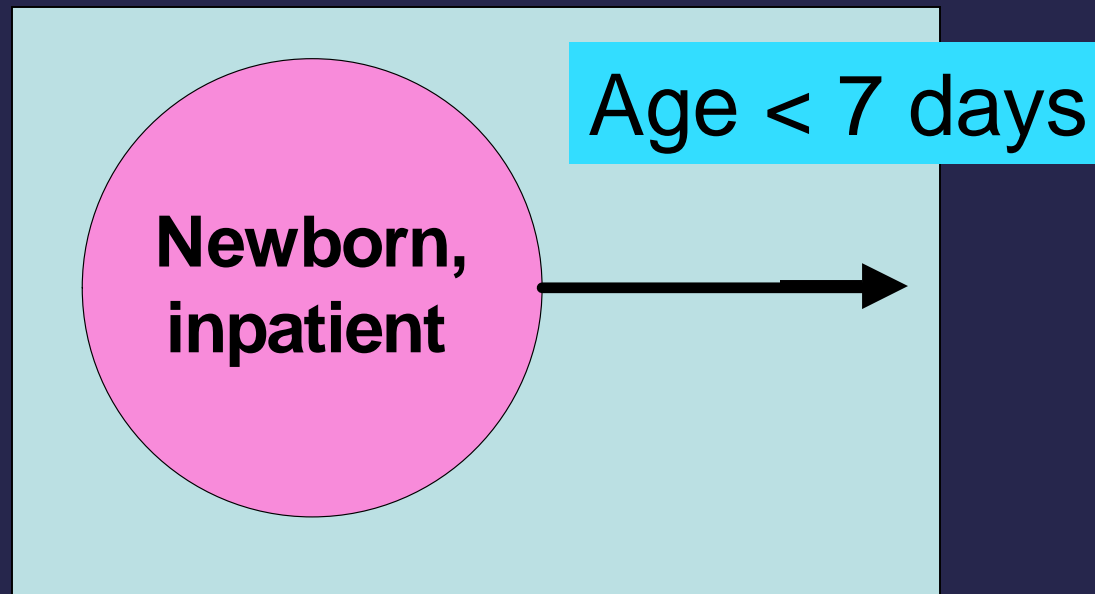
SAGE Execution

- Architecture
- Semantics of the guideline model
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- Example of decision making
- SAGE Actions

Neonate w/ HepB positive mother

Context Node

Obtain and check patient age.



Triggering Event: CIS Admission from ADT System

new-born
in hospital

Triggering Events

© Inpatient hospital admission event

Precondition

◇ age < 7 days

Remember:

How does SAGE process criteria?

- Obtain CIS data (e.g., date of birth)
- Convert Units as required (e.g., lb to grams)
- Use evaluator for expressions
- Compute boolean (true or false)
- Examples:
 - » Age < 7 days
 - » Counting Previous Vaccinations
 - » Mother's HBsAG status
 - » Consent for Immunization



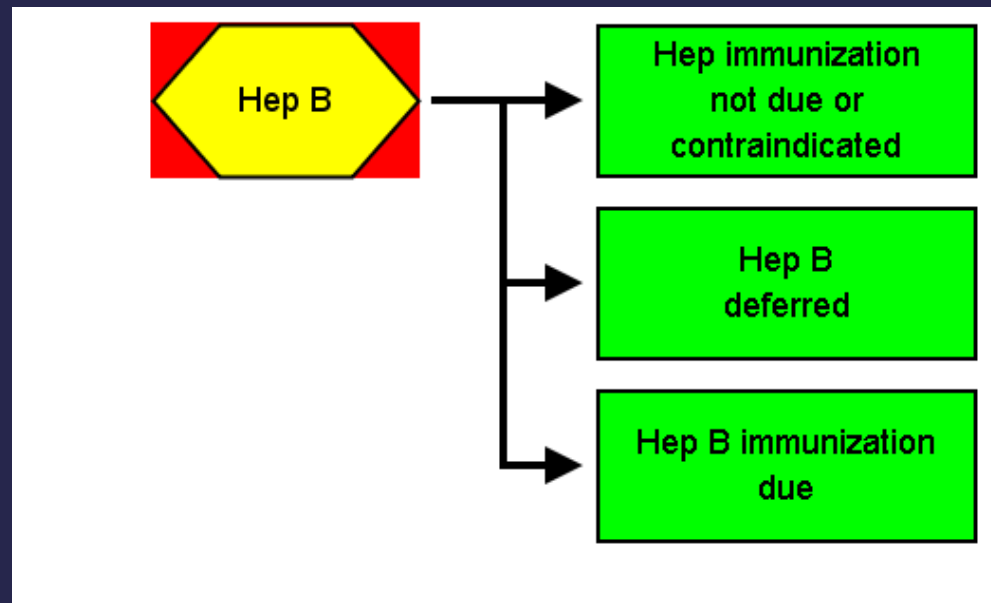
SAGE Execution

- Architecture
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Neonate w/ HepB positive mother

Decision Logic

Hep B vaccination is due.

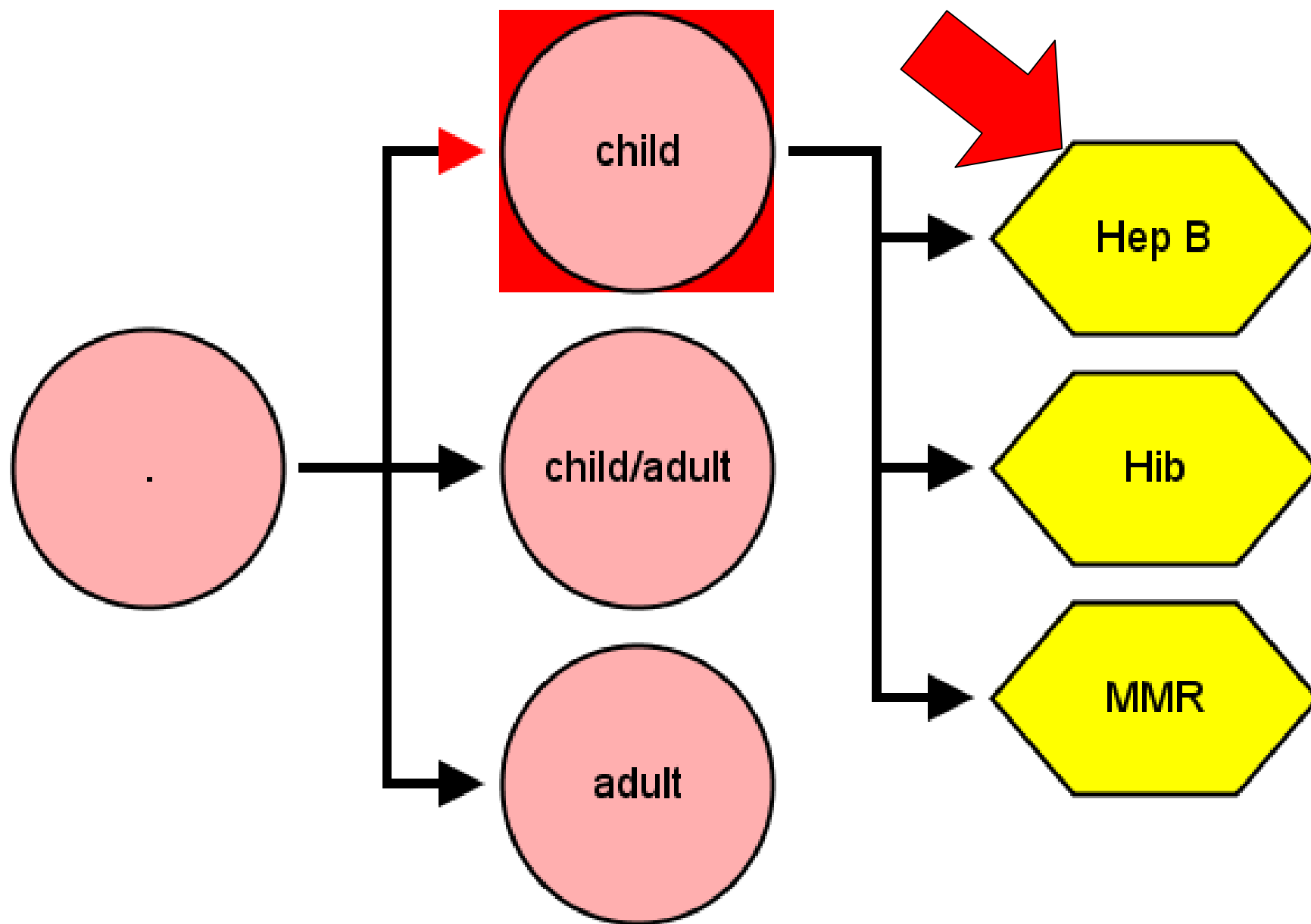


Next

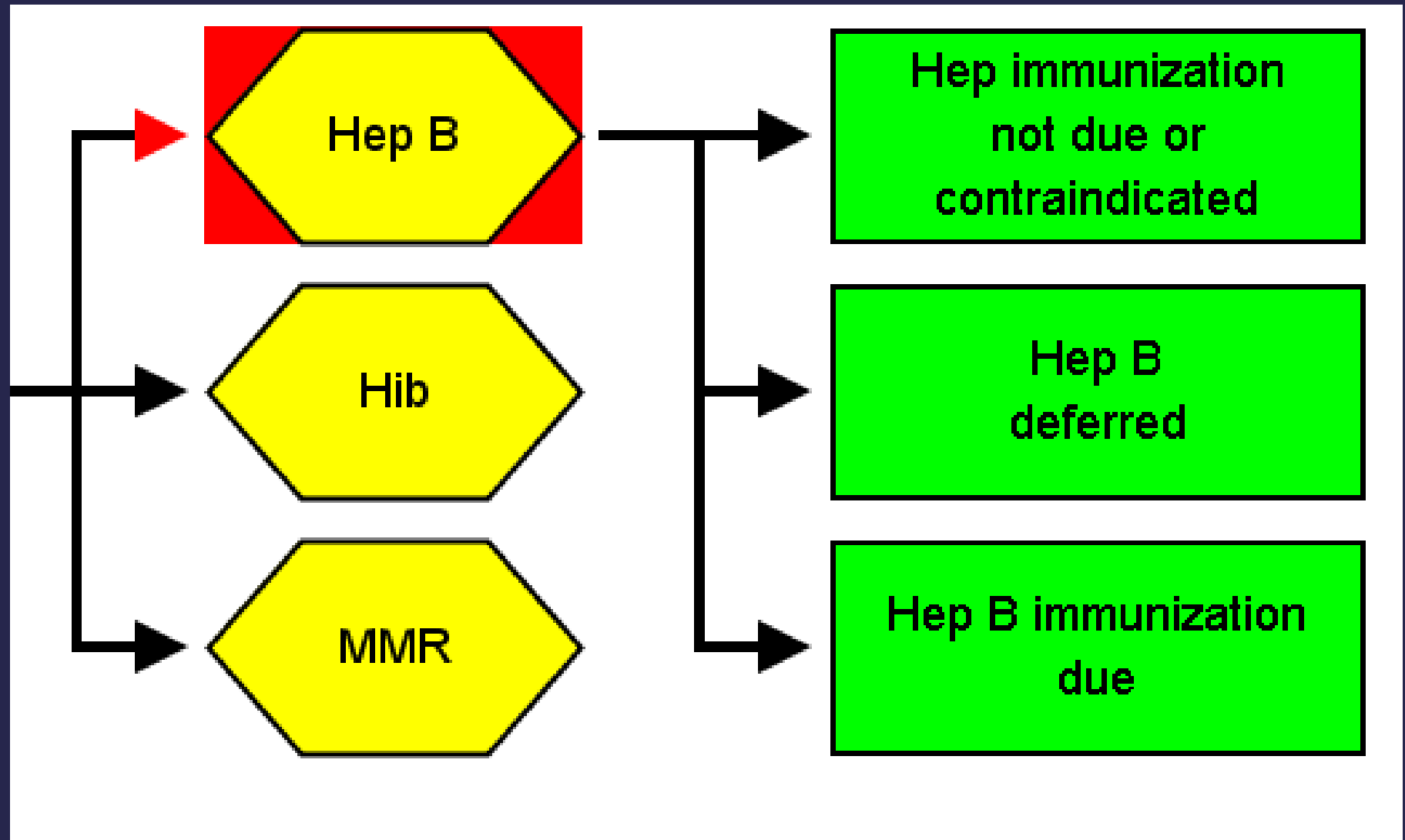
Prev

Pause

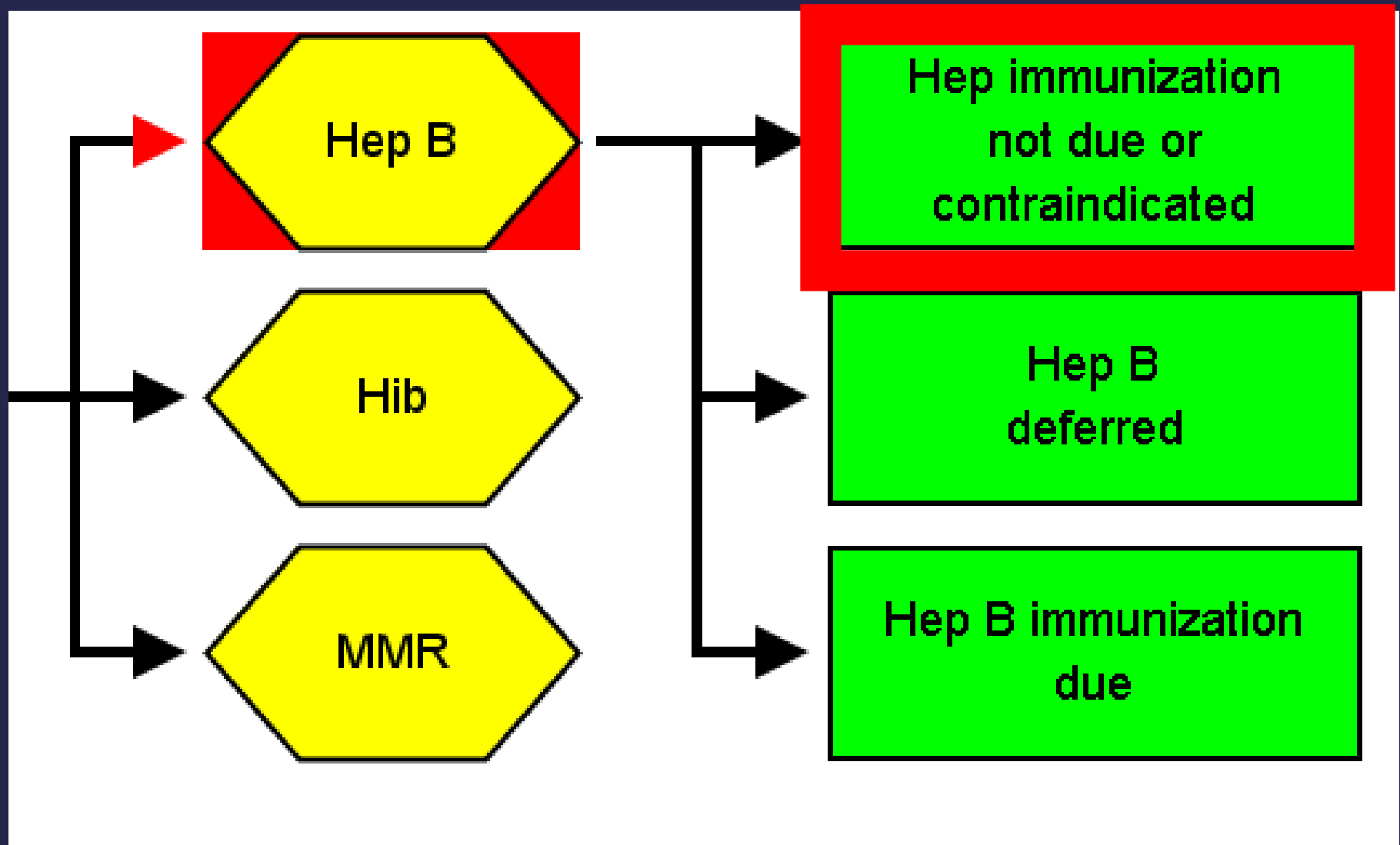
Compute Immunizations / Decision Map



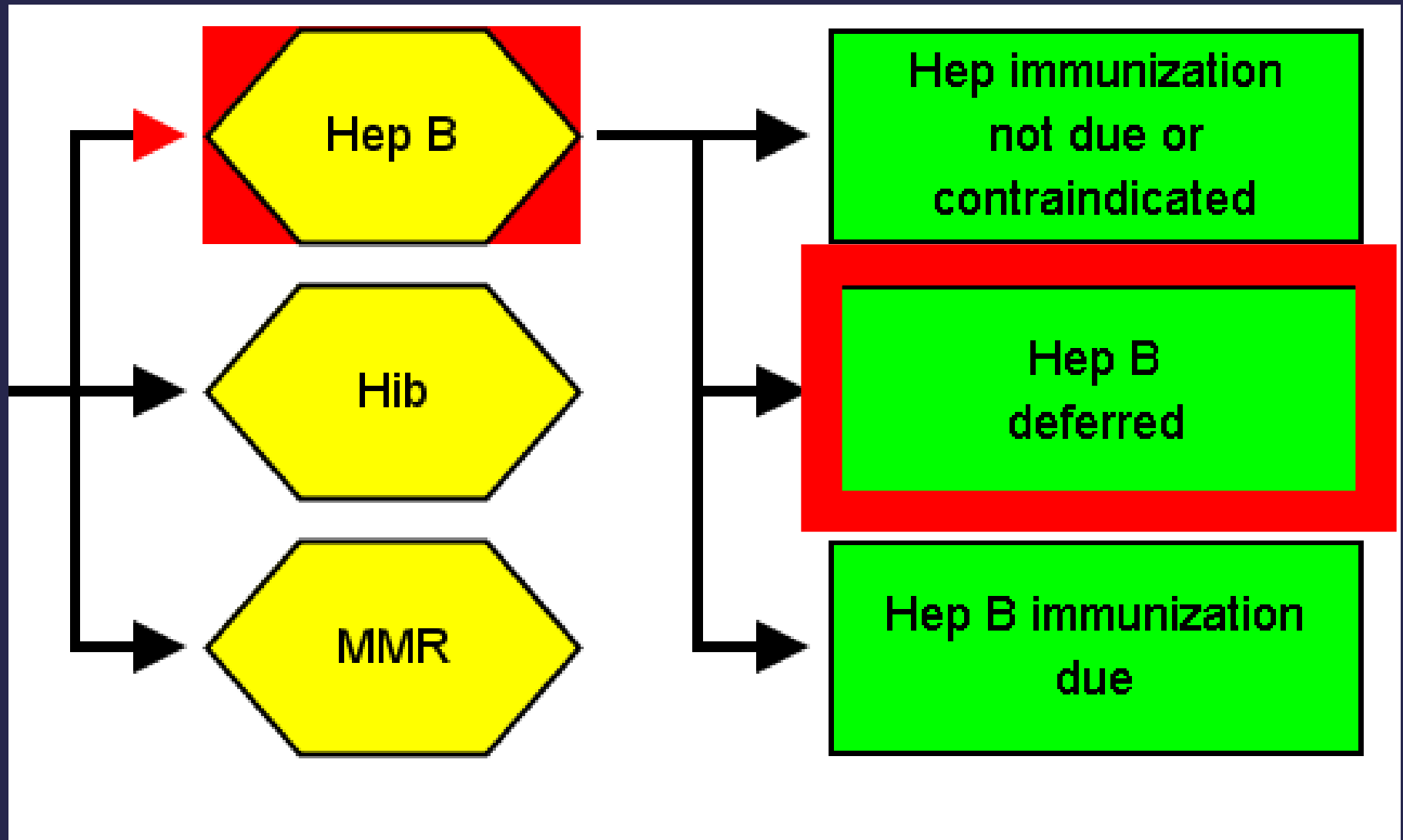
We have 3 possibilities.



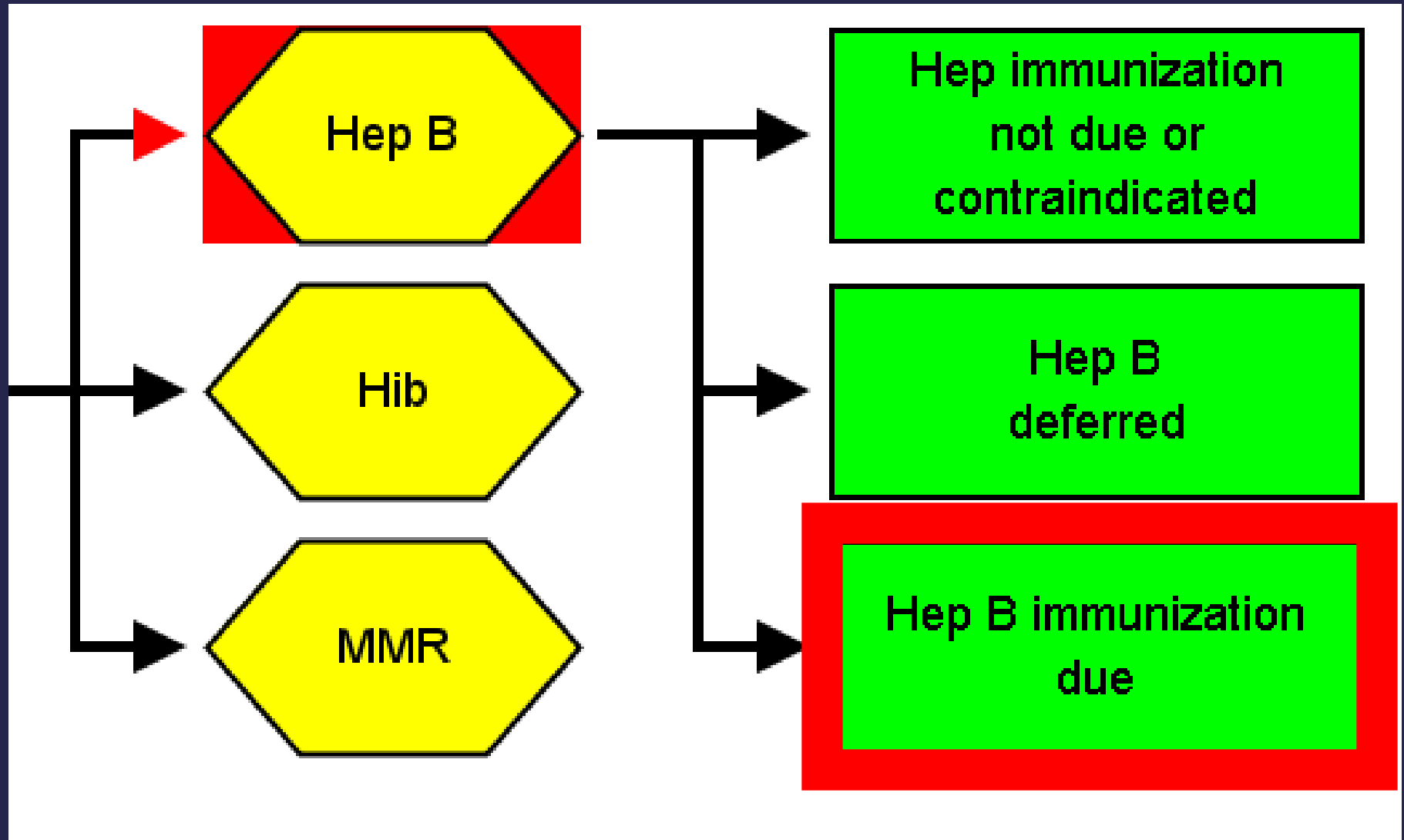
We have 3 possibilities.



We have 3 possibilities.



We have 3 possibilities.



Rule Out: Any 1 of these

Hep B immunization
due

- ❖ Contraindication to Hep B vaccination
- ❖ age \geq 19 years
- ❖ corrected patient acutely ill by judgement of care provider

Rule Out: Any 1 of these

Hep B immunization
due

Anaphylaxis

- ❖ Contraindication to Hep B vaccination
- ❖ age \geq 19 years
- ❖ corrected patient acutely ill by judgement of care provider

Rule Out: Any 1 of these

Hep B immunization
due

- ❖ Contraindication to Hep B vaccination
- ❖ age \geq 19 years
- ❖ corrected patient acutely ill by judgement of care provider

Anaphylaxis

Observation today of
SNOMED-CT
39104002 = Illness

Rule In, ANY ONE OF:

Hep B immunization
due

- ❖ no previous hep B vaccination and age \geq 1 months
- ❖ 1 previous Hep B dose, 4 weeks after first dose
- ❖ 2 Hep B doses already, 8 weeks after last dose, 16 weeks after 1st dose
- ❖ Birth dose given with early delivery of 3rd dose
- ❖ 1 previous Hep B dose, age \geq 1 months, mother Hep B+
- ❖ age $<$ 7 days, previous hep B vaccination

Rule In, ANY ONE OF:

Hep B immunization
due

- ◆ no previous hep B vaccination and age \geq 1 months **3**
- ◆ 1 previous Hep B dose, 4 weeks after first dose **2**
- ◆ 2 Hep B doses already, 8 weeks after last dose, 16 weeks after 1st dose **3**
- ◆ Birth dose given with early delivery of 3rd dose **4**
- ◆ 1 previous Hep B dose, age \geq 1 months, mother Hep B+ **3**
- ◆ age $<$ 7 days, previous hep B vaccination **3**

Rule In, ANY ONE OF:

Hep B immunization
due

All N-ary criteria

- ❖ no previous hep B vaccination and age \geq 1 months **3**
- ❖ 1 previous Hep B dose, 4 weeks after first dose **2**
- ❖ 2 Hep B doses already, 8 weeks after last dose, 16 weeks after 1st dose **3**
- ❖ Birth dose given with early delivery of 3rd dose **4**
- ❖ 1 previous Hep B dose, age \geq 1 months, mother Hep B+ **3**
- ❖ age $<$ 7 days, previous hep B vaccination **3**

Rule In, ANY ONE OF:

Hep B immunization
due

All of these
must be true

- ❖ age < 7 days
- ❖ # of hep B doses = 0
- ❖ Mother Hep B+

All N-ary criteria

- ❖ no previous hep B vaccination and age >= 1 month **2**
- ❖ 1 previous Hep B dose, 4 weeks after first dose **2**
- ❖ 2 Hep B doses already, 8 weeks after last dose or 16 weeks after 1st dose **3**
- ❖ Birth dose given with early delivery of 3rd trimester **4**
- ❖ 1 previous Hep B dose, age >= 1 months, mother Hep B+ **3**
- ❖ age < 7 days, previous hep B vaccination **3**

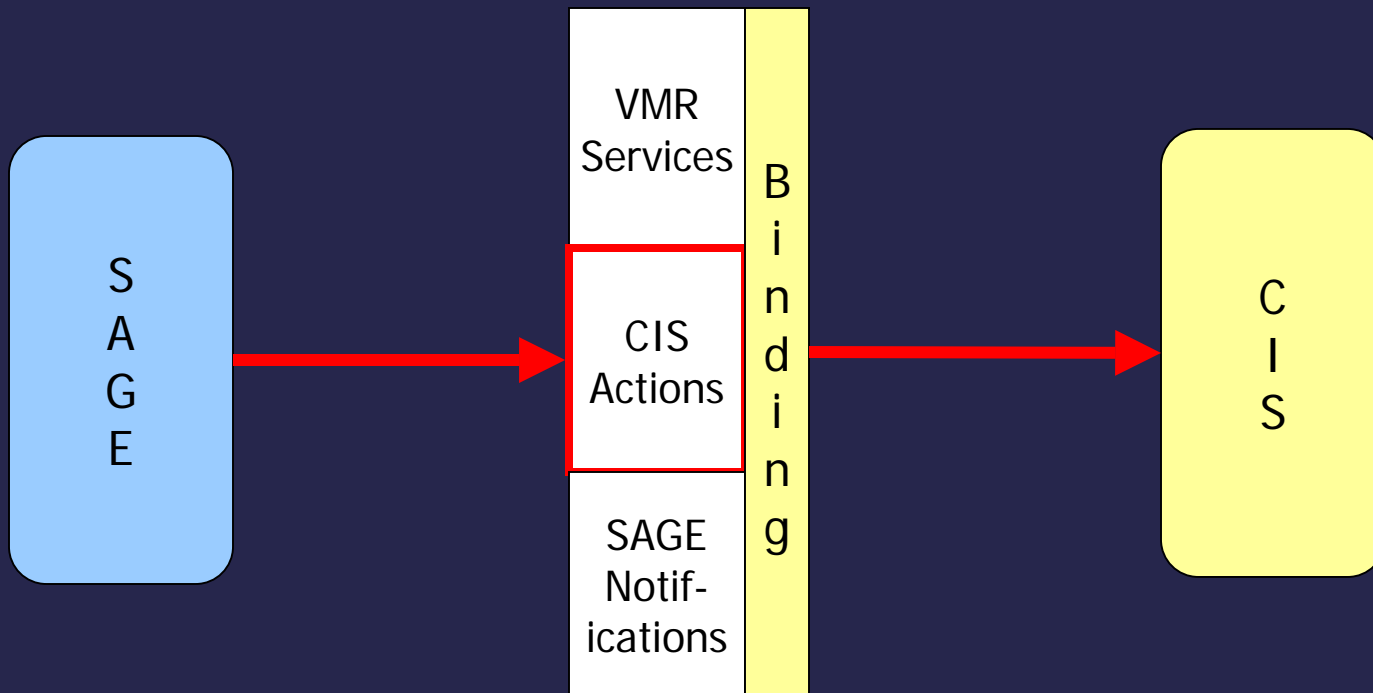
SAGE Execution

- Architecture
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- **SAGE Actions**

Neonate w/ HepB positive mother

SAGE Actions

Pending orders created in the CIS.





Desktop

Current Patient List: PERS: Sage Testing Attending, Ray

MRN	Patient Name	Other Information
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01005875	STOCK, Marie	
01005883	THOMAS, John	
01005826	TUCKER, Tommy	
01005792	WHITE, Tristan	

Patient List Directory

Freq Folders Avail

List Name	Type	Owner
Hotlist		
CAR Service	CNSS	
Sage Testing	PERS	Attending,
TemporaryList	PERS	Attending,

Select Make Default Make Freq Move/Remove

InBox Messages

All Mine Patient

Notifications	Count
Unsolicited	
You have saved order sessions	4
Message from SAGE Engine	2

Create Resolve Refresh

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

Command Central

Command:
 Active MRN: Global Name Lookup



Desktop

Current Patient List: PERS: Sage Testing Attending, Ray

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01005867	CHAPMAN, Lucy	
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Patient List Directory

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Hotlist		
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Command Central

Command:
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01005826	TUCKER, Tommy	
01005792	WHITE, Tristan	

SAGE Engine has caused 4 pending orders to be created in the CIS

Patient List Directory

Freq Folders Avail

List Name	Type	Owner
Hotlist		
CAR Service	CNSS	
Sage Testing	PERS	Attending,
TemporaryList	PERS	Attending,

Select Make Default Make Freq Move/Remove

InBox Messages

All Mine Patient

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Message from SAGE Engine	2

Create Resolve Refresh

Command Central

Command:

Active MRN: Global Name Lookup



Desktop

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01005792	WHITE, Tristan	

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

SAGE Engine has caused 4 pending orders to be created in the CIS



Patient List Directory

Freq Folders Avail

List Name	Type	Owner
Hotlist		
CAR Service	CNSS	
Sage Testing	PERS	Attending,
TemporaryList	PERS	Attending,

Select Make Default Make Freq Move/Remove

InBox Messages

All Mine Patient

Notifications	Count
Unsolicited	
You have saved order sessions	4
Message from SAGE Engine	2

Create Resolve Refresh

Command Central

Command:

Active MRN: Global Name Lookup

LastWord Client

File Patient Session Navigate Help

My Saved Order Sessions

Patient	Mrn	Previous Owner	Save Date Time	Comment
JONES, Baby boy	01005842	ATTENDING, R	15Aug2003 10:41	Hep B surface antige
JONES, Baby boy	01005842	ATTENDING, R	15Aug2003 10:41	Hepatitis B core ant
JONES, Baby boy	01005842	ATTENDING, R	15Aug2003 10:41	Hepatitis B Vac Reco
JONES, Baby boy	01005842	ATTENDING, R	15Aug2003 10:41	Hepatitis B Immune G

Activate Details Forward Issue Delete Cancel

DCXSESSQ | 252-ADF1 | 0.1 | LWGH

SAGE Engine has caused 4 pending orders to be created in the CIS



Patient Problem List

All Active Add:

Status	Problem Description	Gde
A	Newborn exposure to maternal h...	

Guidelines

Update Problem

Patient Order List

Expand Change Context Prefs Save Session

Current order	ST	Sub ST	Start Date	Problem
Hepatitis B Vac Recombinant Inj inj	U	READY	15Aug2003	

Modify

D/C

Issue

Common Orders

MEDICATIONS

Order Selection

- Order is Historical
- Order is Prescription

Select Order

Button Dept: MED

Order Text Search:



Patient Problem List

All Active Add:

Status	Problem Description	Gde
A	Newborn exposure to maternal h...	

Guidelines Update Problem

Patient Order List

Expand Change Context Prefs Save Session

Current Order	ST	Sub ST	Start Date	Problem
Hep B surface antigen level	U	READY	10May2004	

Modify D/C Issue

Dept Buttons Common Order Sets Search Meds Personal Prescriptions

Common Orders

MEDICATIONS

Order Selection

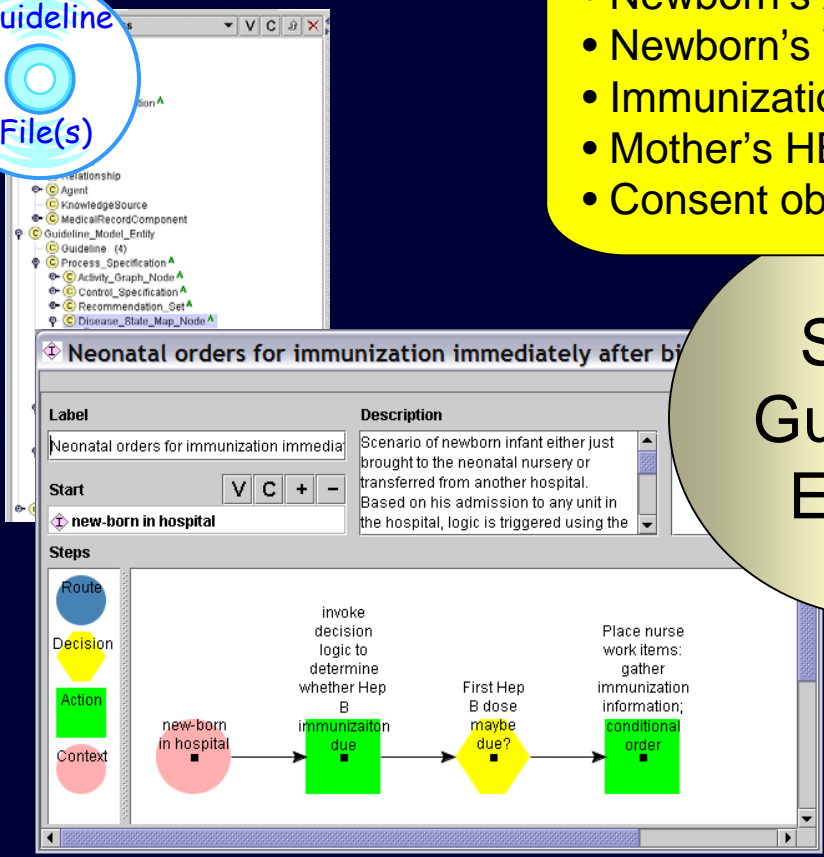
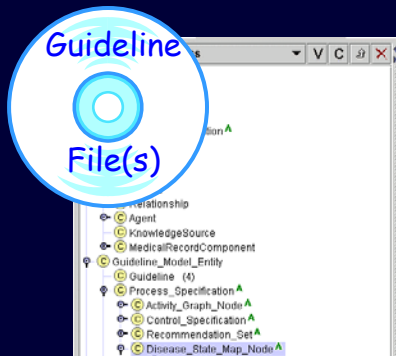
Order is Historical
 Order is Prescription

Select Order

Order Text Search:

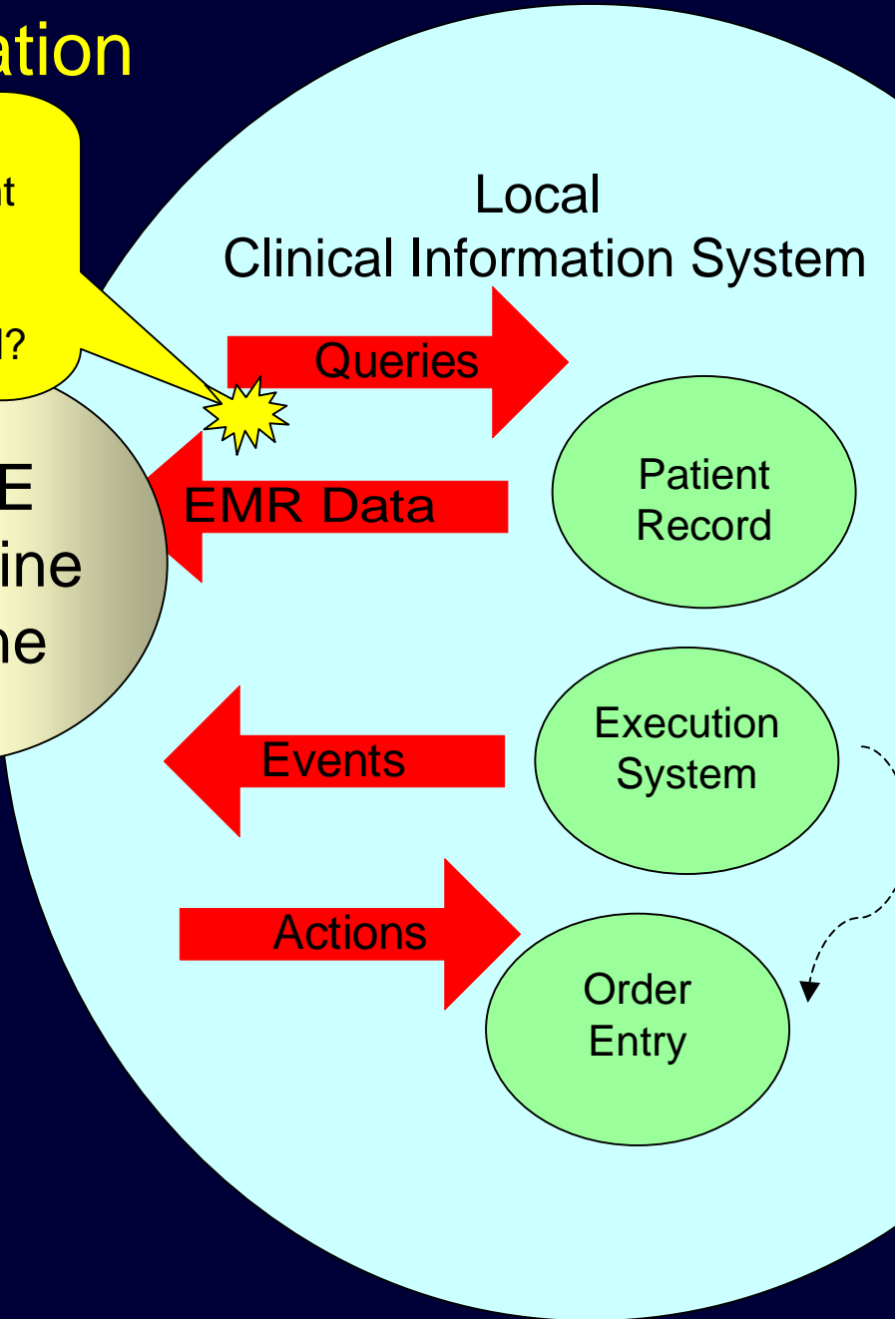
Button Dept:

SAGE Guideline Execution: Neonatal Orders for Immunization



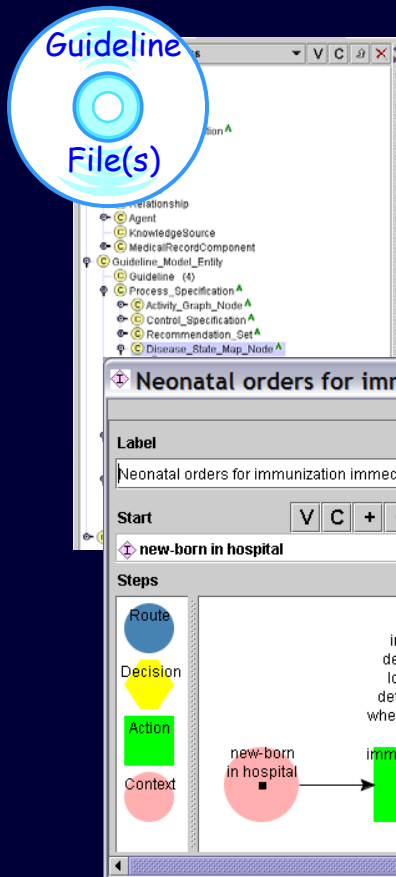
- Newborn's Age
- Newborn's Weight
- Immunization Hx
- Mother's HBsAG
- Consent obtained?

SAGE
Guideline
Engine



Guideline content will be executed by the SAGE Guideline Engine, interacting with the CIS via standards-based interfaces.

SAGE Guideline Execution: Neonatal Orders for Immunization



- Detect newborn admission
- Detect updates to newborn's EMR

SAGE
Guideline
Engine

Local
Clinical Information System

Queries

EMR Data

Patient
Record

Events

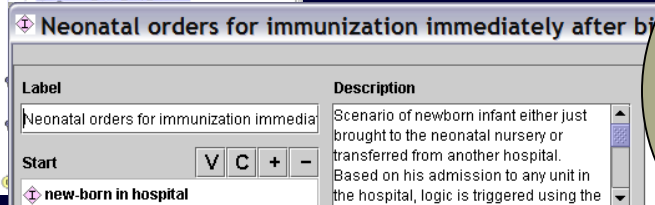
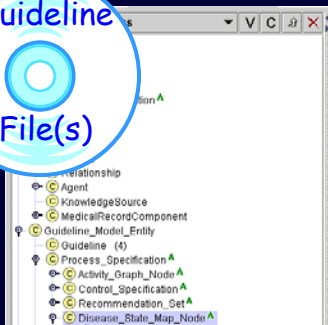
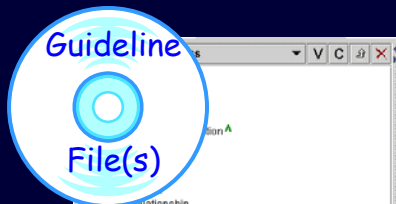
Execution
System

Actions

Order
Entry

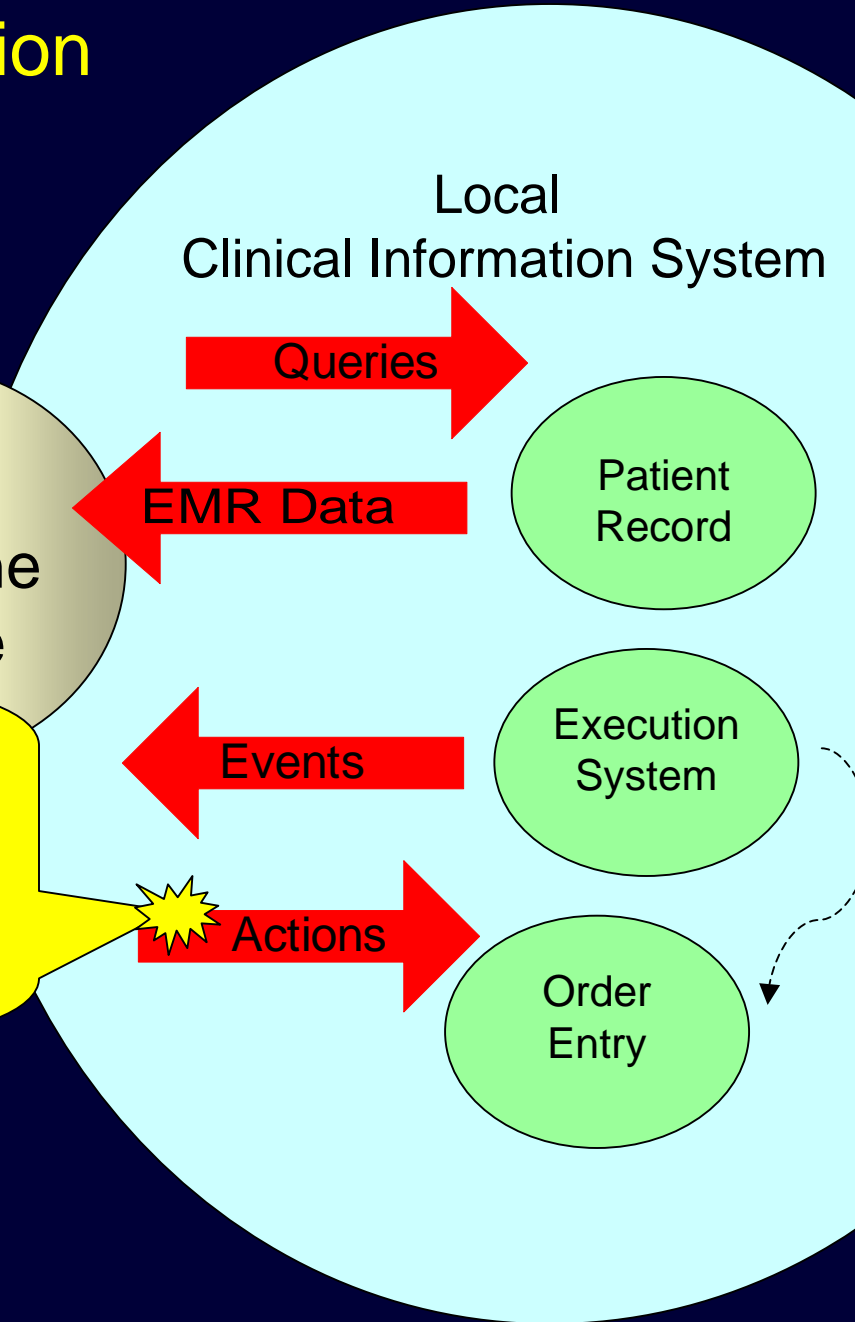
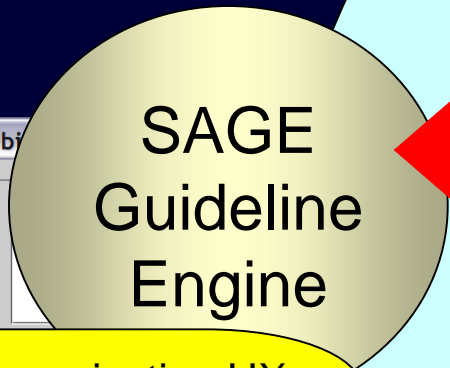
Guideline content will be executed by the SAGE Guideline Engine, interacting with the CIS via standards-based interfaces.

SAGE Guideline Execution: Neonatal Orders for Immunization



- Remind nurse to check immunization HX
- Remind nurse to check contraindications
- Remind nurse to obtain consent
- Create recommended (pending) immunization orders in CIS
- Notify physician of new pending orders

Guideline content will be executed by the SAGE Guideline Engine, interacting with the CIS via standards-based interfaces.



The model is robust and
comprehensive.

**Another patient
in the clinic...**



Normal 2 month old

(2) Suzy Smith

- ✓ *2 month old, female*
- ✓ Vital signs: WNL
- ✓ no recent illness
- ✓ *no prior immunizations*
- ✓ routine well-baby checkup



Normal 2 month old

Expected Results for Suzy Smith

- *Immunizations due*
 - ✓ *Hep B*
 - ✓ *IPV*
 - ✓ *DTaP*
 - ✓ *Hib*
 - ✓ *PCV 7*

