A Model-Integrated Approach to Implementing Individualized Patient Care Plans Based on Guideline-Driven Clinical Decision Support and Process Management

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Goals

- Develop a tool to manage a ubiquitous, complex clinical process in a hospital setting
- Deploy the tool in the ICUs and ED
- Evaluate changes in clinical practice
- Iterate, targeting other clinical problems

Protocols

Motivation

Protocol Instances

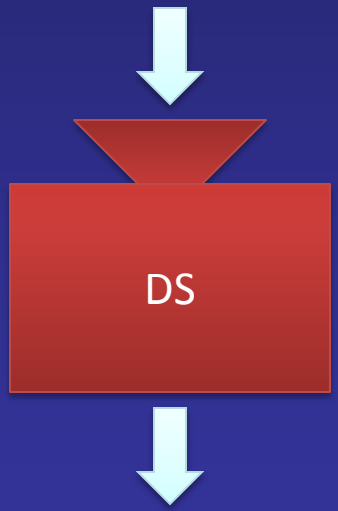
- Standardize the care of patients
  - The use of evidence-based guidelines for managing complex clinical problems has become the standard of practice, but guidelines are protocols not patient care plans
  - ➢ *To be truly effective, protocols must be deployed as customized, individualized clinical care plans*
- Tackle the challenges of knowledge transfer
  - Division of responsibilities among different individuals and teams in acute care settings (e.g.: ICUs)
  - Managing new findings and updates in best practice

The Plan

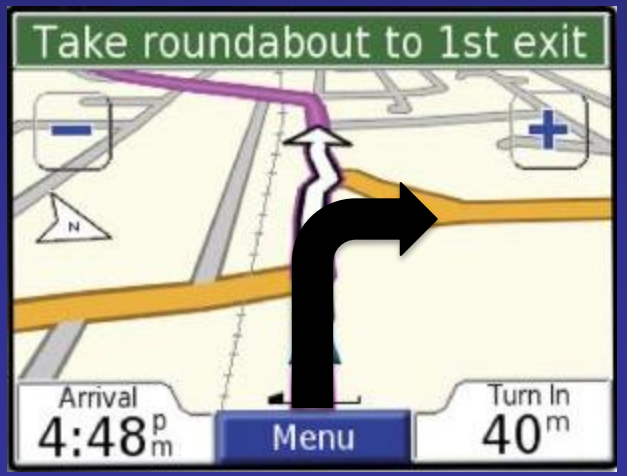
Support the overall clinical process management by generating individualized care plans from evidence-based clinical protocols

Decision Support vs. Process Management

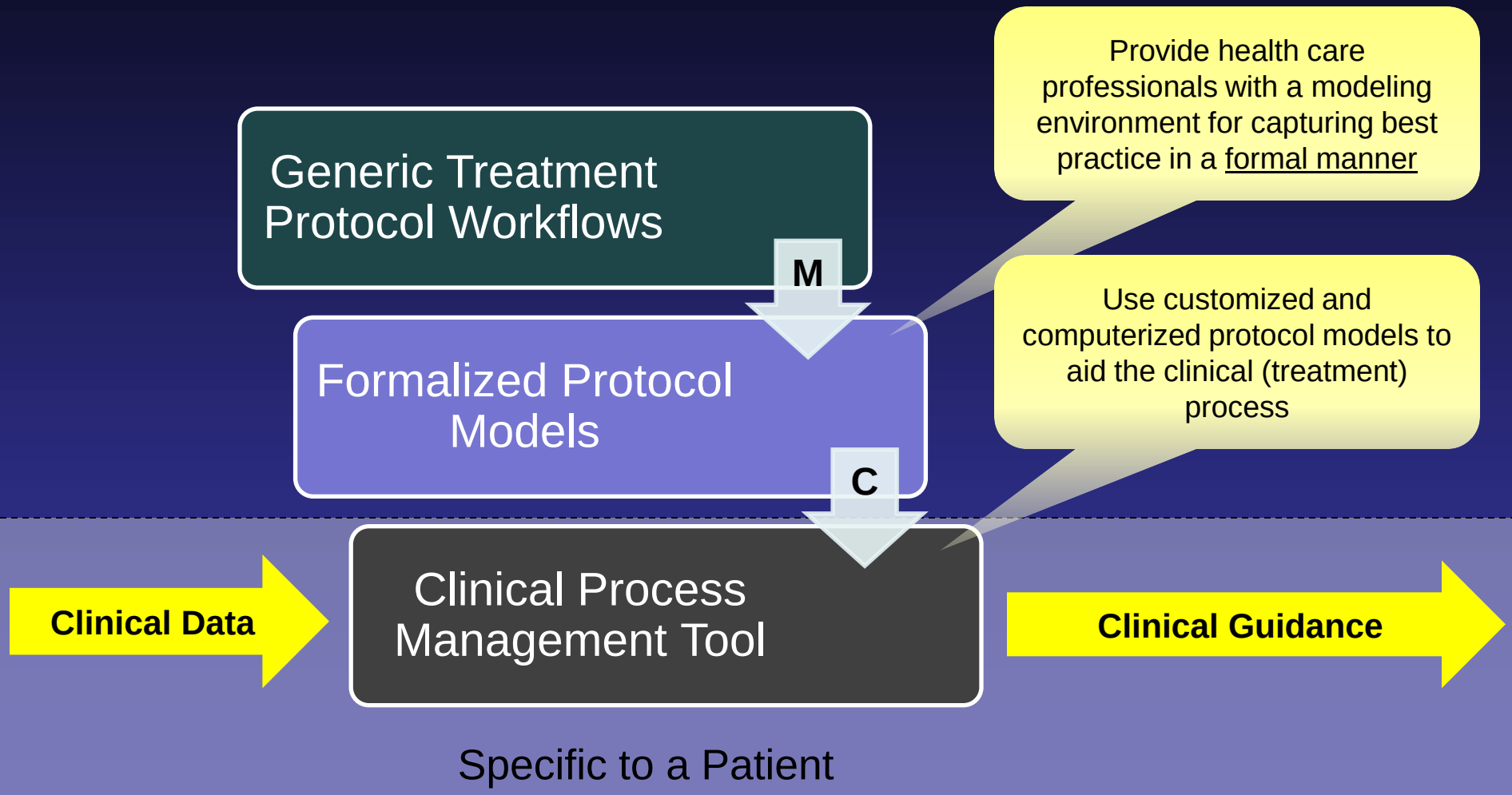
- Decision Support
  - decisions/answers to specific questions at independent points during treatment



- Process Management
  - guides you trough a complete treatment, it's like a GPS, it also recalculates if not followed



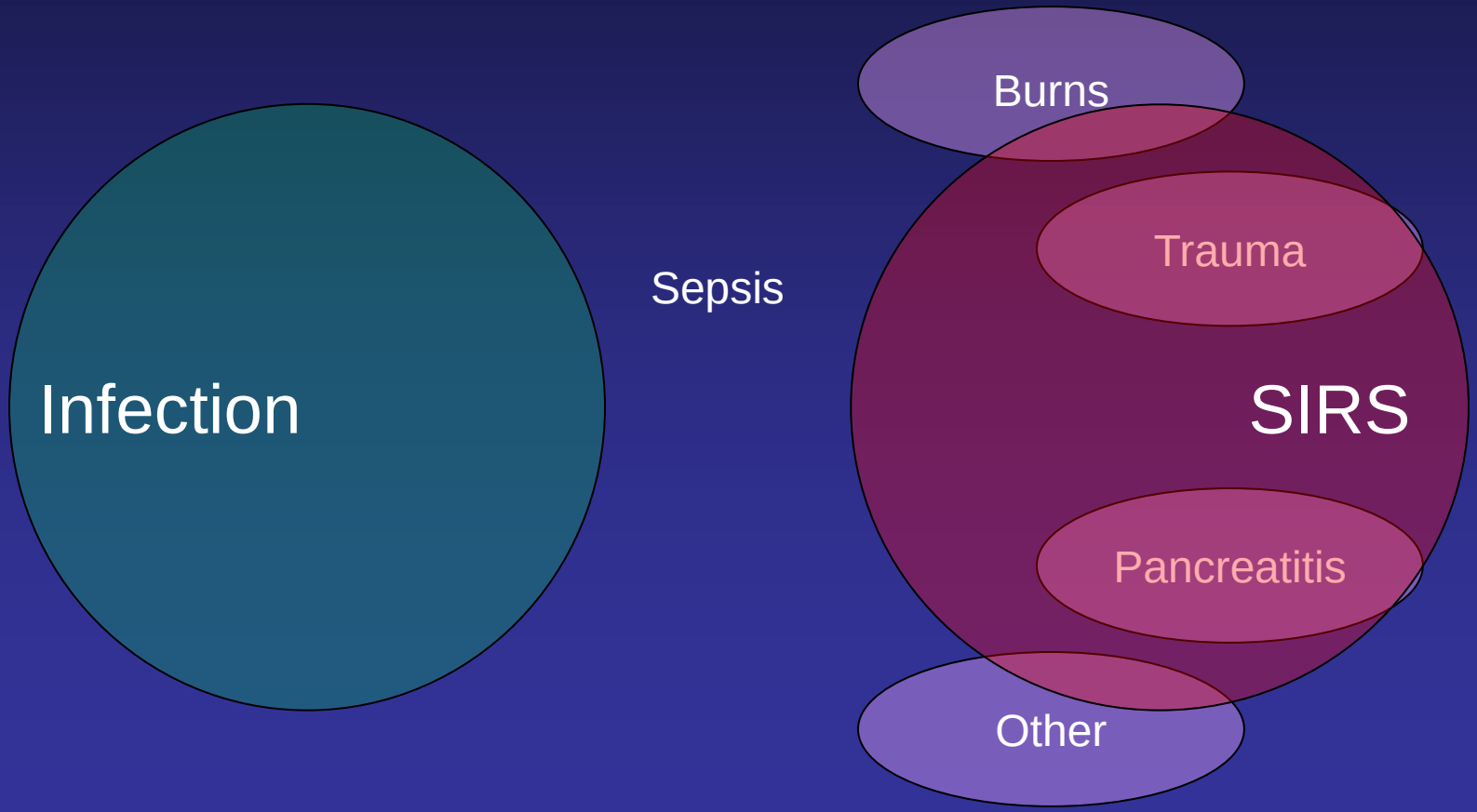
Clinical Process Management



Protocol Case Study: Sepsis

Sepsis

a serious medical condition caused by the body's response (Systemic Inflammatory Response Syndrome) to an infection



Why Sepsis?

It is common

- 1-3 cases per 1000 in the population
- 750,000 cases in the US annually
- Although no definitive age, gender, racial, or geographic boundaries,
- Mostly men, typically in their 6th or 7th decade, immunocompromised

It is deadly

- Mortality approaches 30% in patients with severe sepsis
- Mortality roughly correlates with the number of dysfunctional organ systems
- On average, patients have 2-3 organs failing at presentation to the ICU

It is expensive

- Average hospital stay is 3-5 weeks for severe disease
- Average patient bill is tens of thousands of dollars
- $17 B annual expenditure to the US healthcare
- 40% of all ICU costs?

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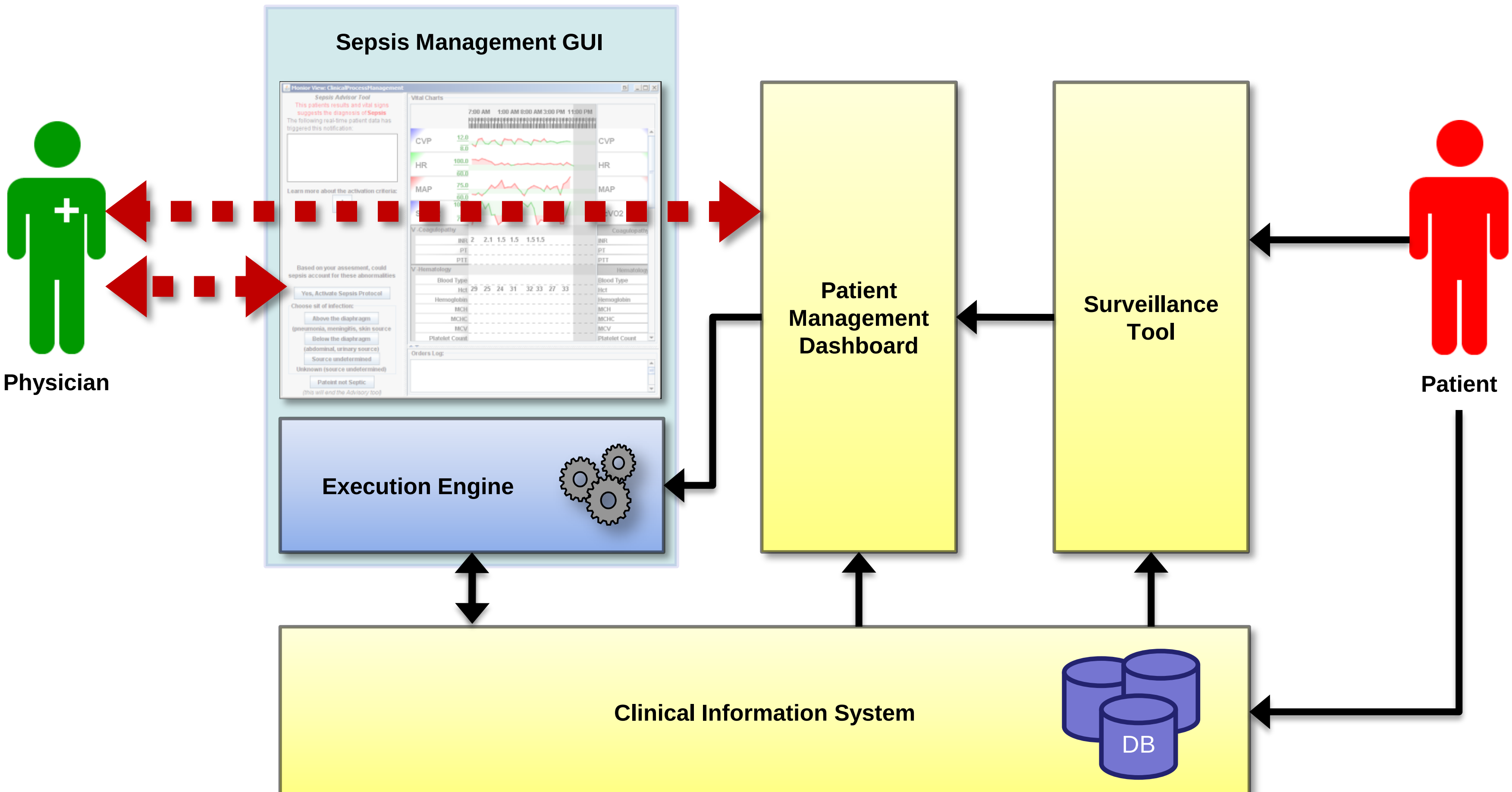
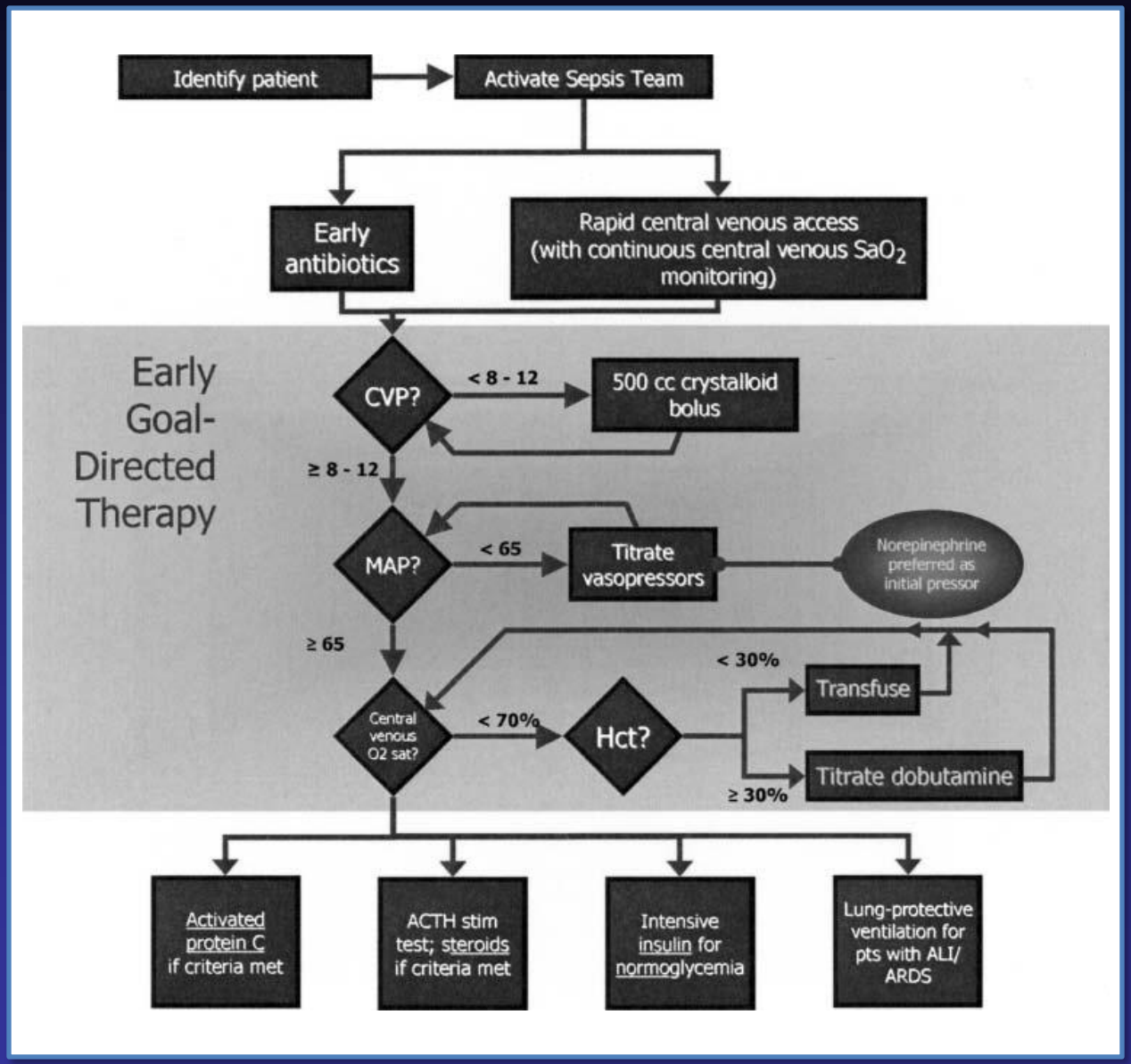
Proposed Architecture



Current … modified SIRS criteria
recommendations based on live patient data

Evidence-based guidelines for Sepsis



*A Blueprint for a Sepsis Protocol, Shapiro et. al., ACAD EMERG MED d April 2005, Vol. 12, No. 4

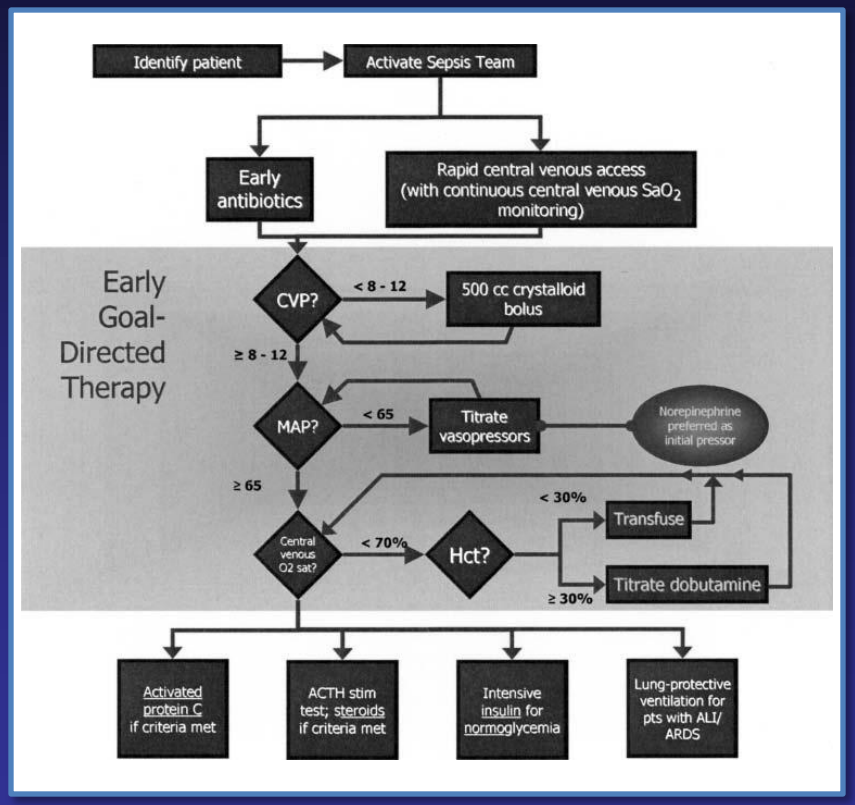
GME approach

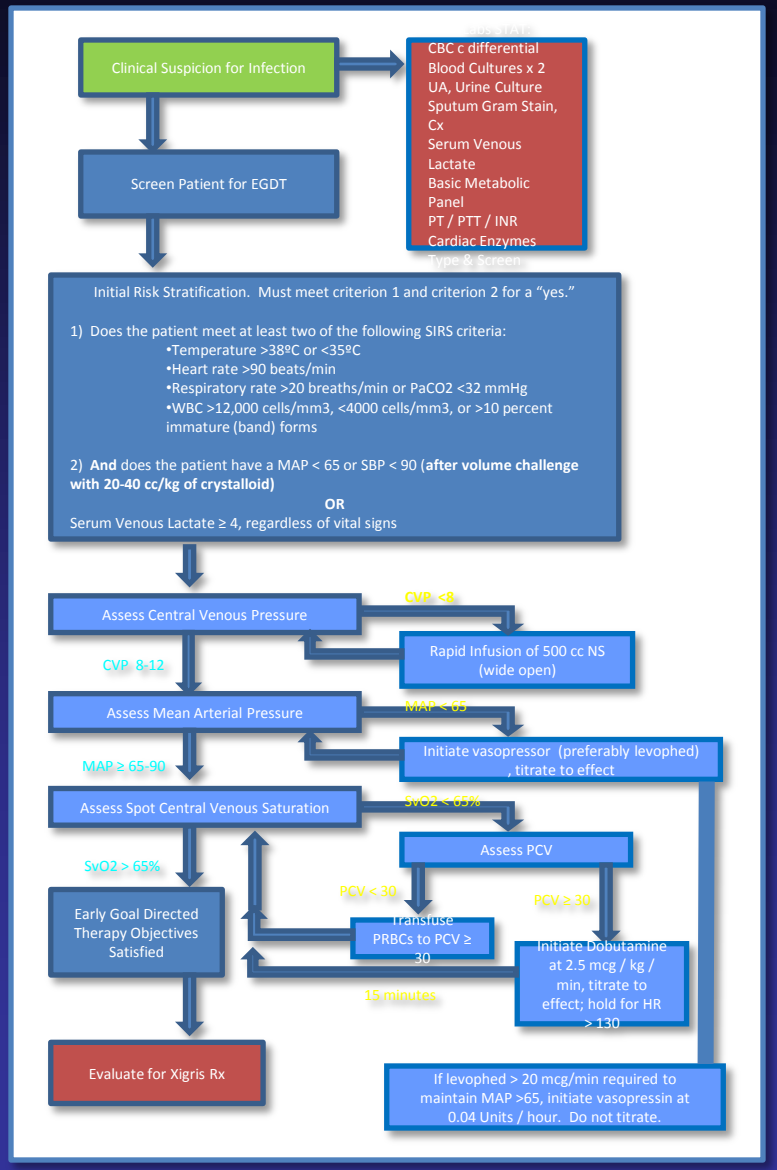
1. Development of abstractions in Domain-Specific Modeling Languages (DSMLs)
2. Construction of the models: capturing the key elements of operation
3. Translation (interpretation) of models
4. Execution and simulation of models

Creating a modeling language for representing treatment protocols (1-2)

- We started out with the flow diagrams available in current literature (for treating sepsis)

First iteration



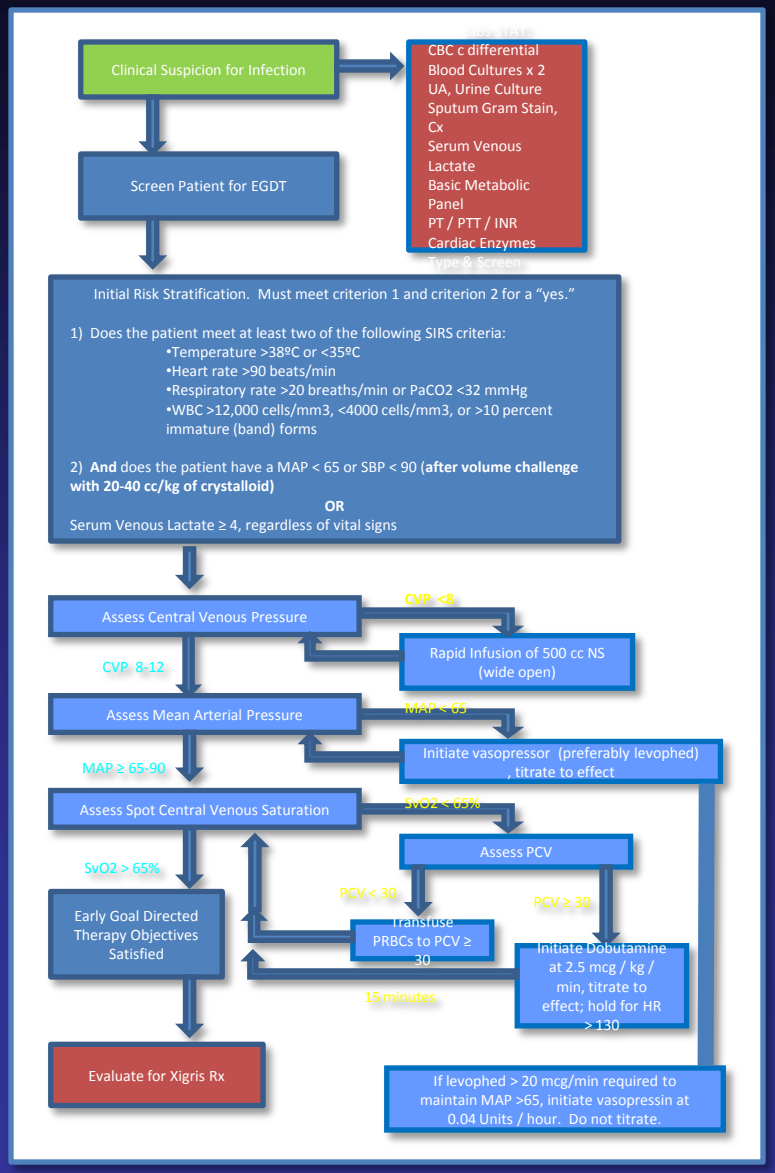


*A Blueprint for a Sepsis Protocol, Shapiro et. al., ACAD EMERG MED d April 2005, Vol. 12, No. 4

Creating a modeling language for representing treatment protocols (1-2)

- We started out with the flow diagrams available in current literature (for treating sepsis)
- Rigid structure, simple operational semantics, but cumbersome
  - jumping around in the tree causes a messy representation

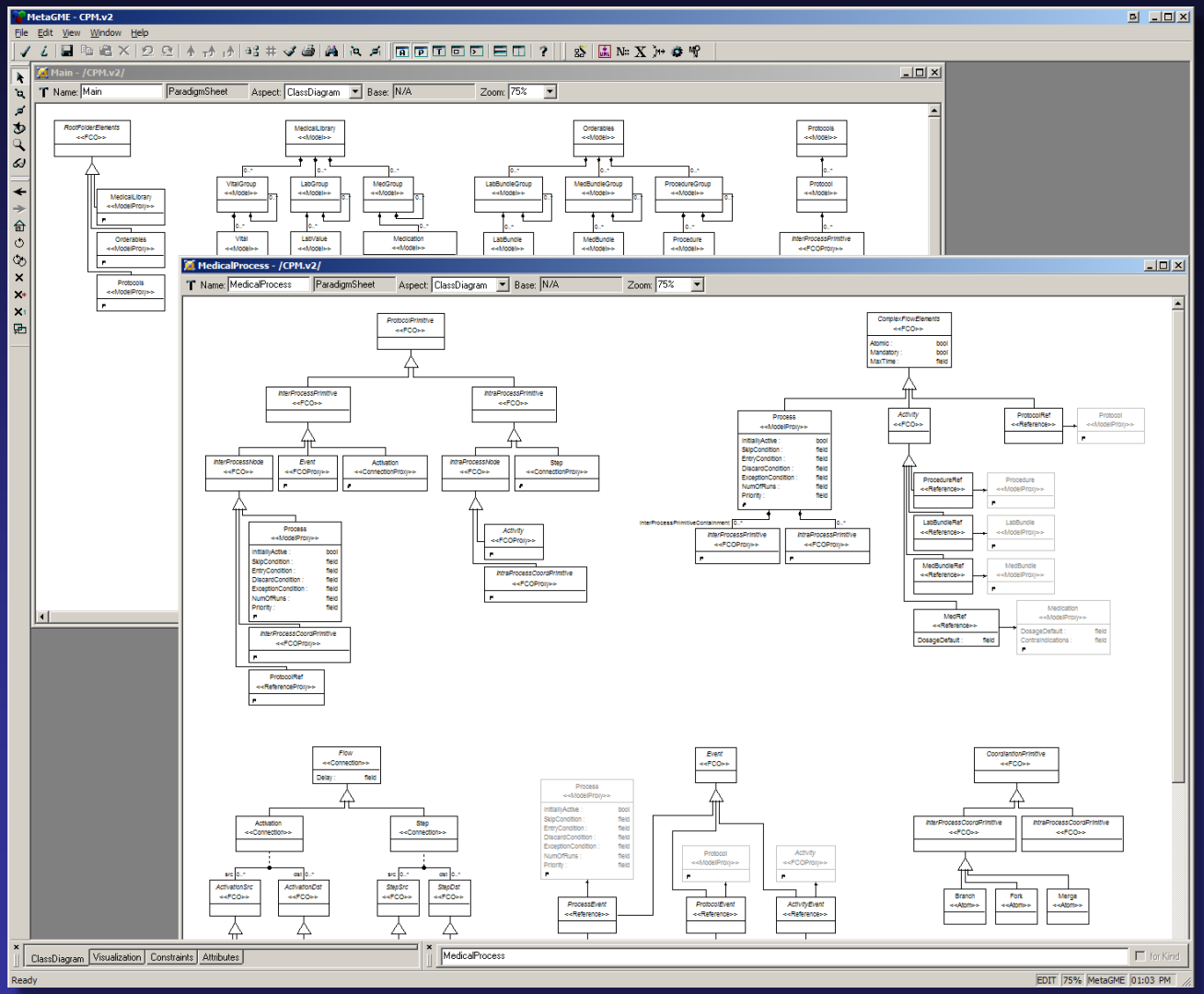
Iterations: indentifying bundles



Clinical Process Modeling Language (CPML)

- CPML supports the design, specification, analysis, verification, execution and validation of complex clinical treatment processes.
- CPML is built upon the Generic Modeling Environment (GME) from the Institute for Software Integrated Systems (ISIS) at Vanderbilt University.

1. Metamodel


MetaGME - CPM.v2
File Edit View Window Help
Main - /CPM.v2/
Name: Main
ParadigmSheet
Aspect: ClassDiagram
Base: N/A
Zoom: 75%
MedicalProcess - /CPM.v2/
Name: MedicalProcess
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Clinical Process Modeling Language (CPML)

- CPML supports the design, specification, analysis, verification, execution and validation of complex clinical treatment processes.
- CPML is built upon the Generic Modeling Environment (GME) from the Institute for Software Integrated Systems (ISIS) at Vanderbilt University.
- There are three main components in CPML

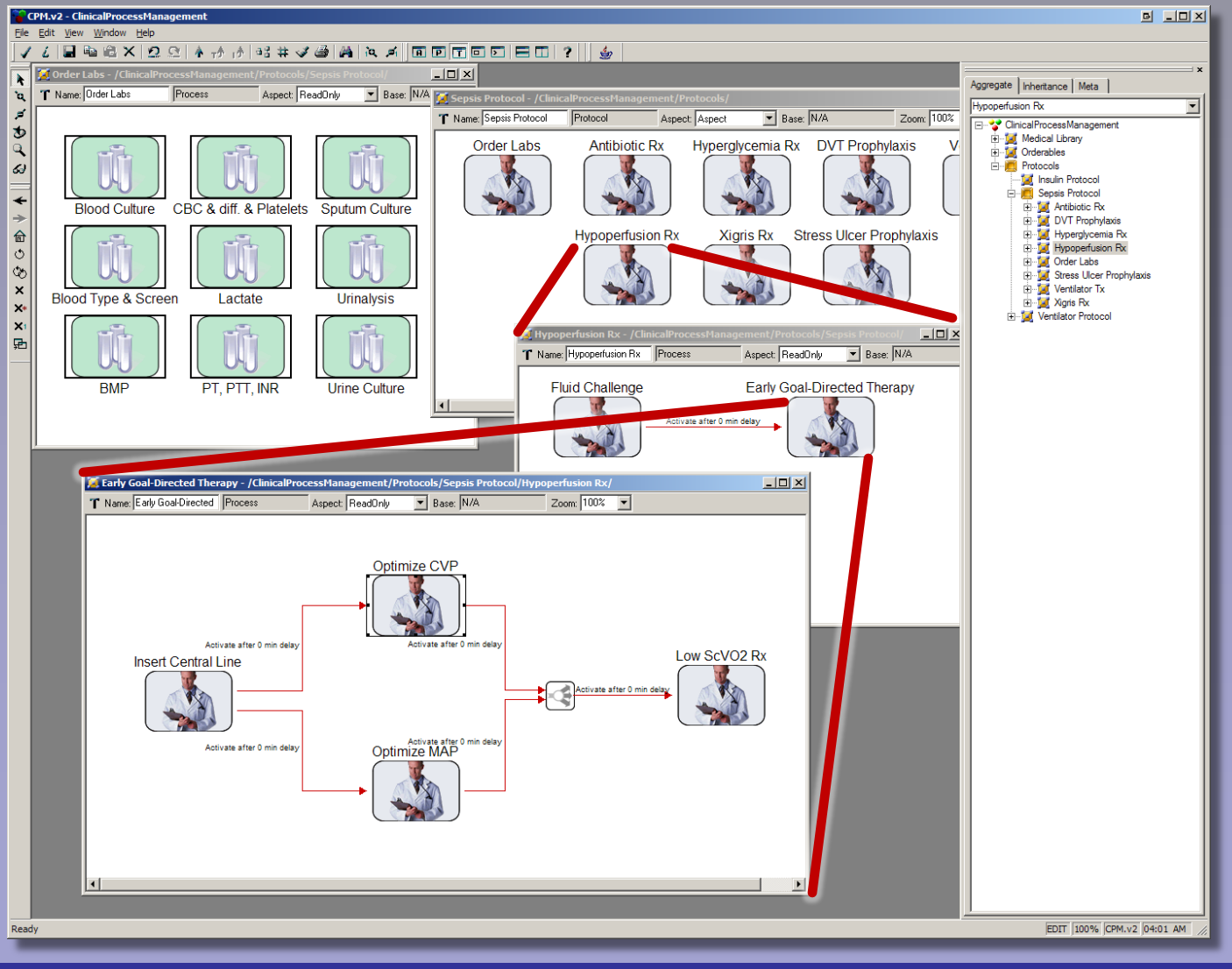
Medical Library
- a placeholder for hierarchically categorizing general medical knowledge

Orderables
- a library for orderable medications, procedures, etc. and
- executable (medical) actions that are specific to a healthcare organization built from the elements defined in the Medical Library)

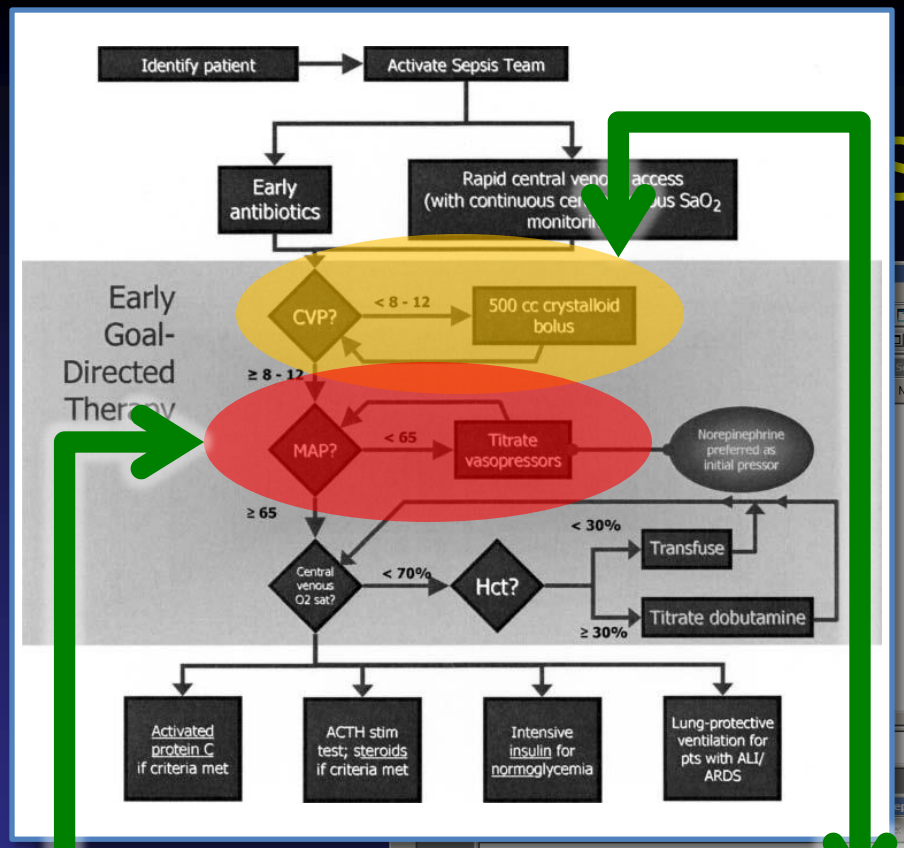
Protocols
- concept, in which treatment protocols can be described

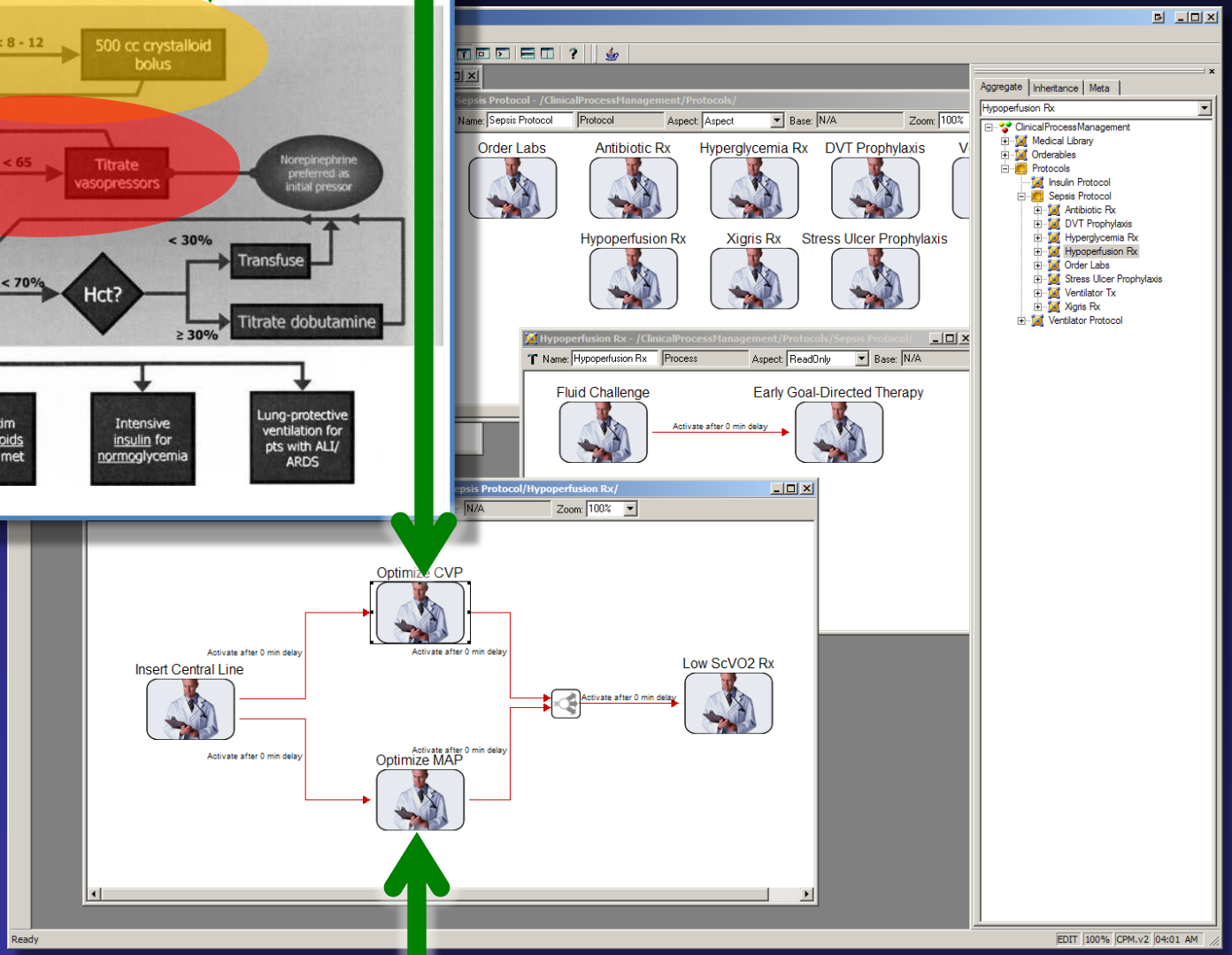
2. Sepsis models

Sepsis Protocol Model



s models

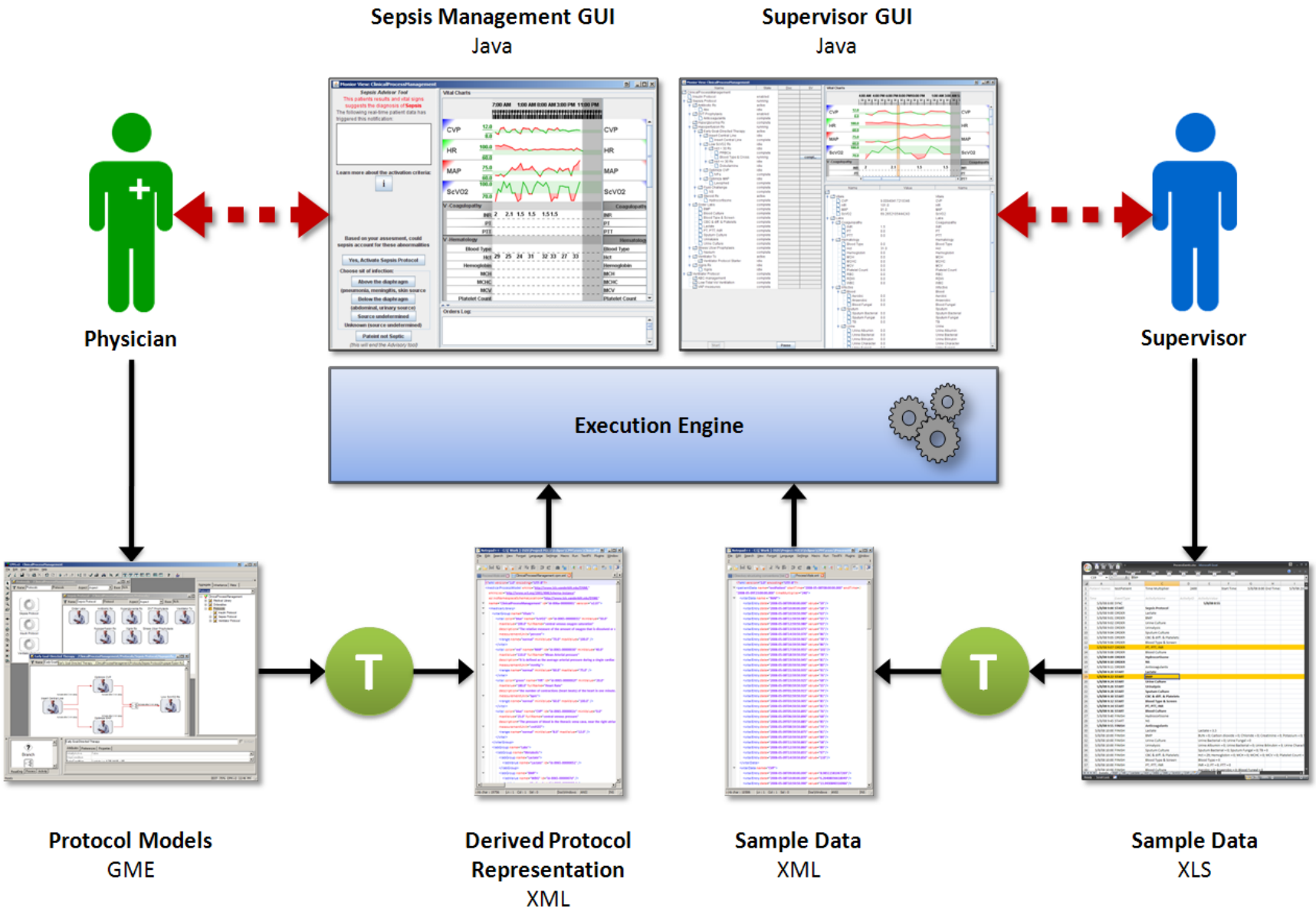

Identify patient
Activate Sepsis Team
Early antibiotics
Rapid central ven access
(with continuous cer us SaO_2
monitori
Early Goal-Directed Ther
CVP?
< 8 - 12
500 cc crystalloid bolus
≥ 8 - 12
MAP?
< 65
Titrate vasopressors
Norepinephrine preferred as initial pressor
≥ 65
Central venous O2 sat?
< 70%
Hct?
< 30%
Transfuse
Titrate dobutamine
≥ 30%
Activated protein C if criteria met
ACTH stim test; steroids if criteria met
Intensive insulin for normoglycemia
Lung-protective ventilation for pts with ALI/ ARDS


Order Labs
Antibiotic Rx
Hyperglycemia Rx
DVT Prophylaxis
Hypoperfusion Rx
Xigris Rx
Stress Ulcer Prophylaxis
Fluid Challenge
Early Goal-Directed Therapy
Activate after 0 min delay
Optimize CVP
Insert Central Line
Optimize MAP
Low ScVO2 Rx
Ready

Benefits for formally representing treatment protocols

- Avoid ambiguity
- Transfer knowledge easier
  - Apprenticeship system
    - learn from experts in actual practice
  - Knowledge maintenance
    - keep up-to-date on current literature
  - Team medicine
    - collective / collaborative clinical management
- Execution/tracking of protocols by a computer becomes possible
- Validation and verification also becomes possible

Experimental Architecture



Results

- Developed a modeling environment for formally representing clinical guidelines and treatment protocols
- Captured a treatment protocol for sepsis using the modeling environment working together with healthcare professionals
- Developed a execution and simulation environment for the validation of the protocol and for the testing of the effectiveness of the tool
- Created execution plan for clinical testing

These techniques are being applied to the management of sepsis in acute care settings at Vanderbilt Medical Center

Future Work

- Integrate with team-based clinical practice
- Interface with existing clinical systems to be able to monitor of all relevant clinical conditions
- Evaluate the effectiveness of the tool using historical outcome metrics
- Experiment with supportive technologies
  - such as large touch-screens
- Verify continuity in existing implementation
- Target other acute and chronic diseases