# Using Medical Devices to Teach Formal Modeling

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## Motivation

Offer suitable training in formal modeling to practicing engineers and domain specialists through educational materials that:

- Show how formal modeling can be used to improve the quality and reliability of software-intensive systems
- Provide guidelines on selecting appropriate modeling approaches for the problem at hand
- Give students hands-on experience in modeling and tool-assisted analysis

## Modeling Notations

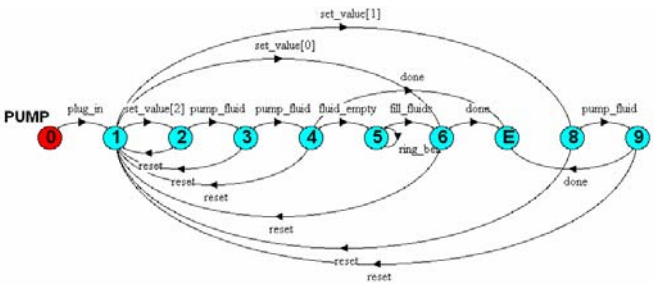
- *State Machines*
  - Provide simple abstractions of complex systems
  - Have intuitive graphical representations
  - Underlie many formalisms
- *Abstract Specification Languages*
  - Based on set theory and logic
  - Provide calculi for building specifications from parts and refining specifications
- *Concurrent Processes*
  - Suitable for modeling interaction
  - Enable analysis of important liveness and safety properties

## Modeling Tasks: Infusion Pump as Unifying Example

Infusion Pump

- Regulates intravenous flow of liquids to patients
- Complex and safety-critical system
- Well-documented features and failures

Students model an infusion pump in a series of tasks focusing on three formal notations.




**Base Specification**
- Single-line pump
- Captures rudimentary behavior, basic flow of processing

**Task 1: Modeling with State Machines**
- Extend model to account for errors, such as occlusions in the line, power failure, etc.
- Decide on additional functionality to model, such as set-up, self-checks on start-up, and pump control by nurse or patient

**Task 2: Modeling with Abstract Specification Languages**
- Extend model to handle multiple delivery lines
- Specify the pre- post-conditions for safe operation
- Specify remedies in the presence of failures
- Use calculus to build larger specifications from smaller ones

**Task 3: Modeling with Concurrent Processes**
- Use concurrency to factor the model into parts representing different concerns
- Parts to model: power system, individual lines, alarms, interface for set-up and pump control

## Model Analysis

Students are asked to analyze their models:

- Which aspects of the pump did you choose to model; which did you choose to leave out?
- State some general properties that your pump guarantees.
- Which recorded failures of real infusion pumps does your model address?
- What ambiguities in the English description of the infusion pump does your specification resolves?

## Reflection

Students answer questions reflecting on their experience:

- What are the strengths and weaknesses of the notation and tools used?
- Under what situation would you recommend using each notation?
- With respect to each notation, what is the single most-important future development that could make it more generally useful to practitioners?