

Control Systems, Modeling and Simulation in Medicine



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Automated Systems for the ICU, OR, and ED

June 4th-5th, 2009

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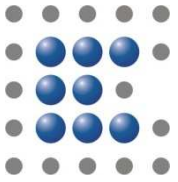
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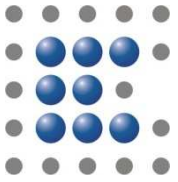
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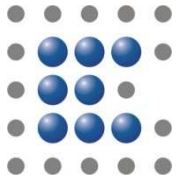
Background

- Primarily automotive/industrial applications
- Why am I here?
 - Want to feel the love
- History
 - Physiology Department, U of MN
 - Ph.D. in Mechanical Engineering (UIUC)
 - Powertrain Research, Ford Motor Company
 - Vice-President, Emmeskay, Inc.
 - Engineering consulting
 - Model-based system development



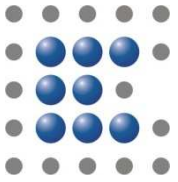
Modeling Philosophy

- “All models are wrong, some are useful”
 - George Box
- Models take many forms
- “Mirror, mirror on the wall...”
- A good model is worth an infinite amount of data
- Modeling is a specialty
 - Outcome strongly depends on qualifications

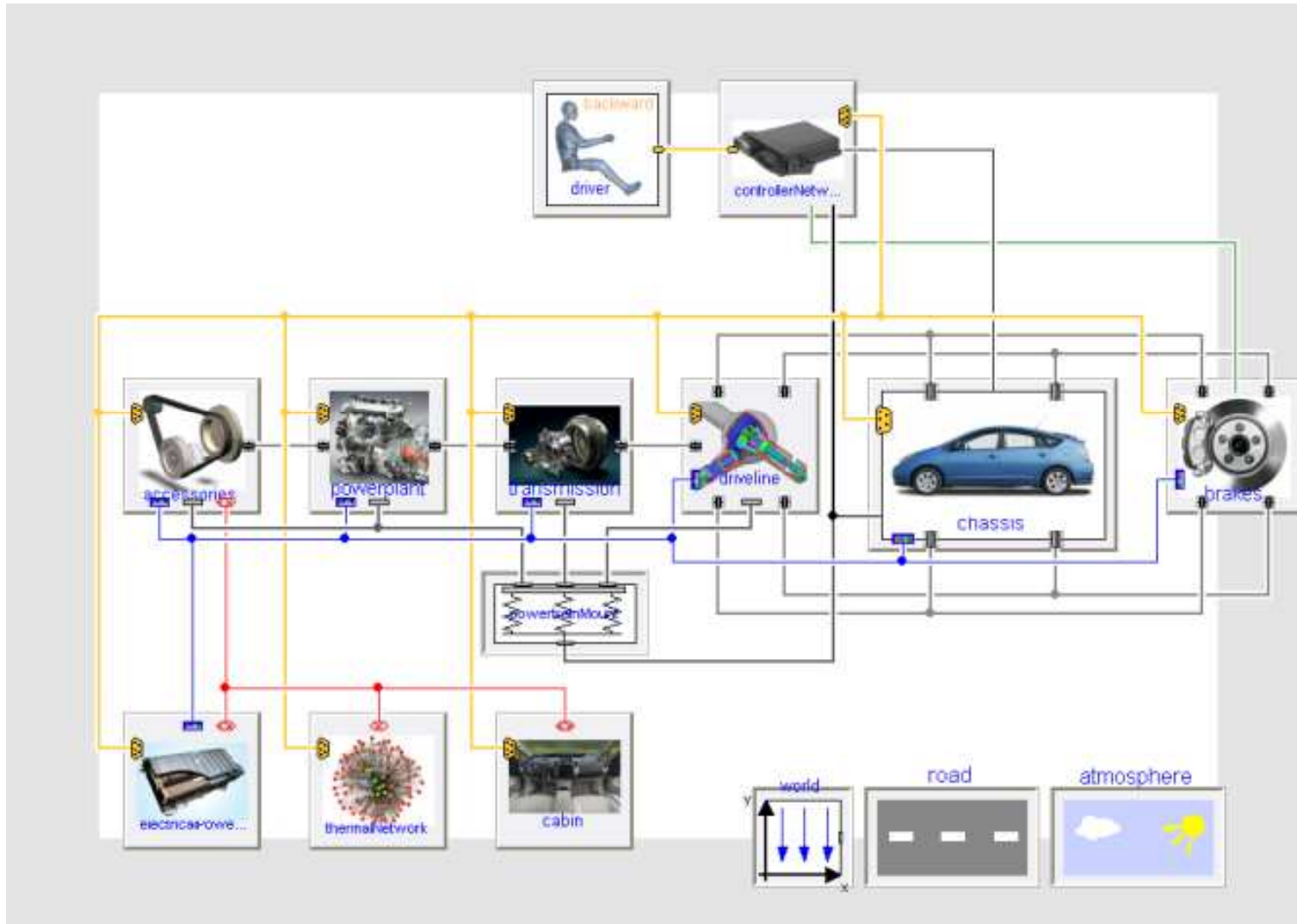


Modeling Practice

- Hybrid dynamic systems
- Enterprise considerations
 - Interoperability/Exchange
 - Scalability
 - Deployment
 - Standards
- Interesting technologies
 - SBML
 - Modelica

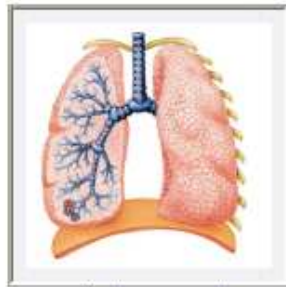


Modeling – Architectures and CM

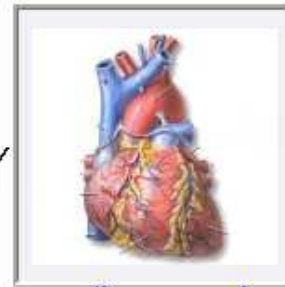




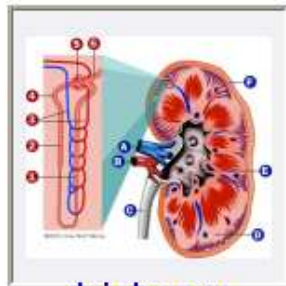
Physiological Architecture



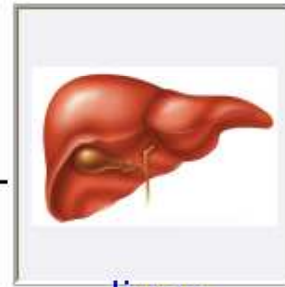
respiratory_system



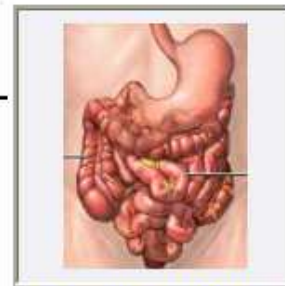
cardio_vascular



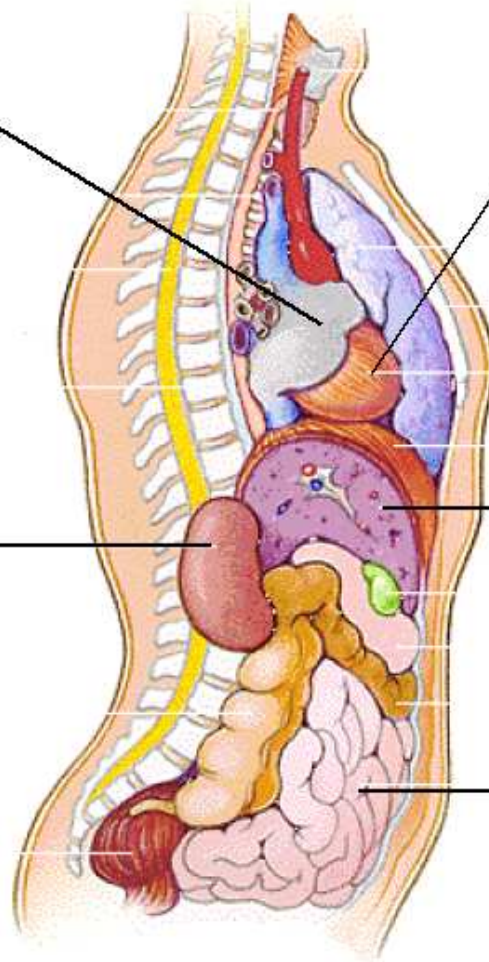
kidney



liver



digestive_system

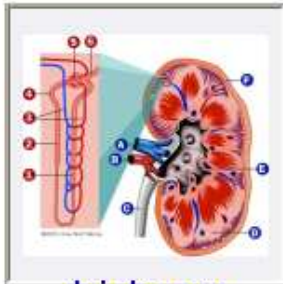




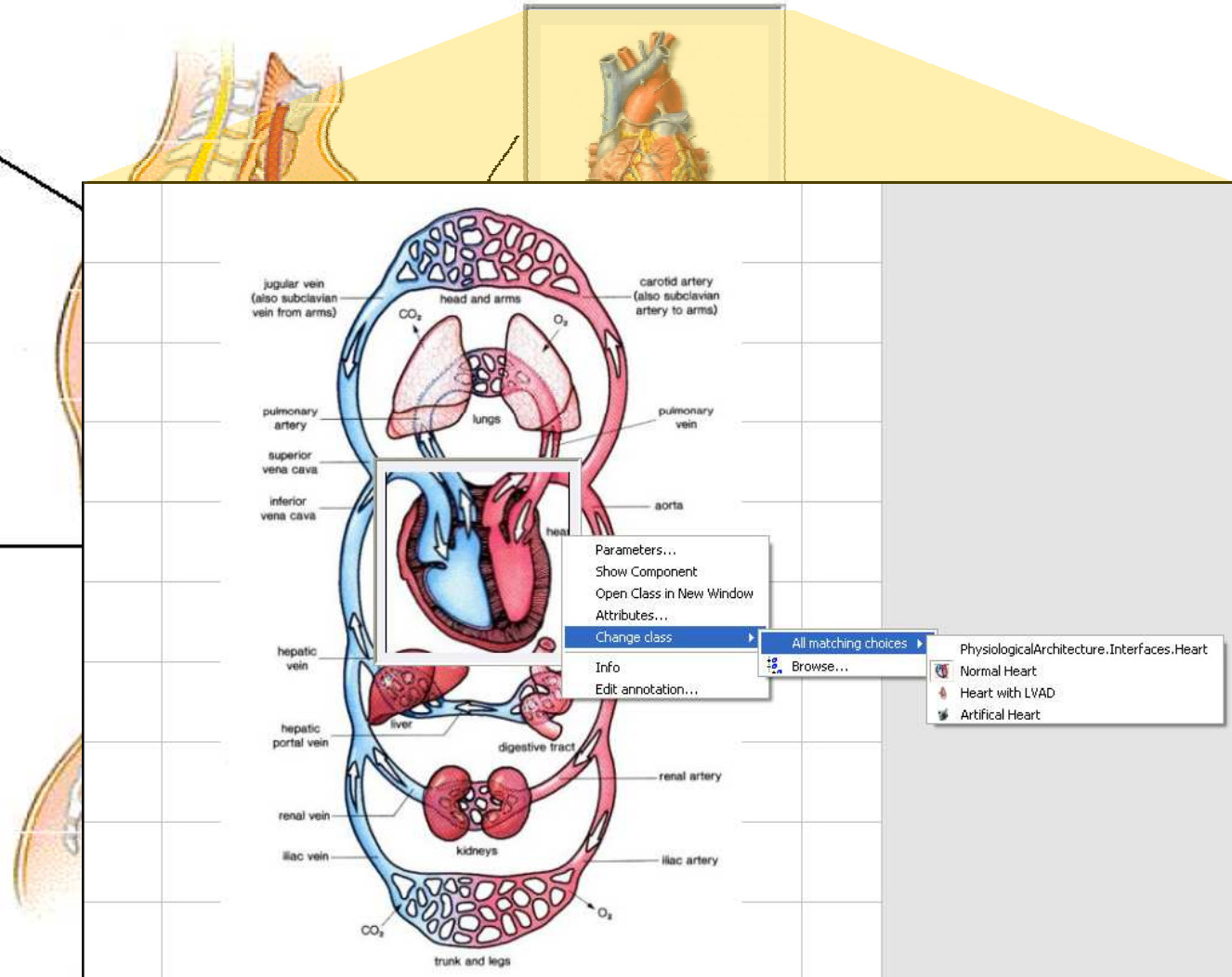
Physiological Architecture



respiratory_system



kidney

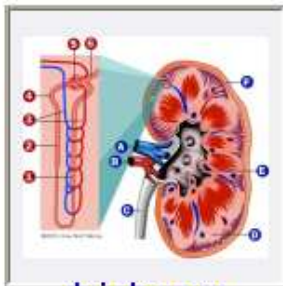




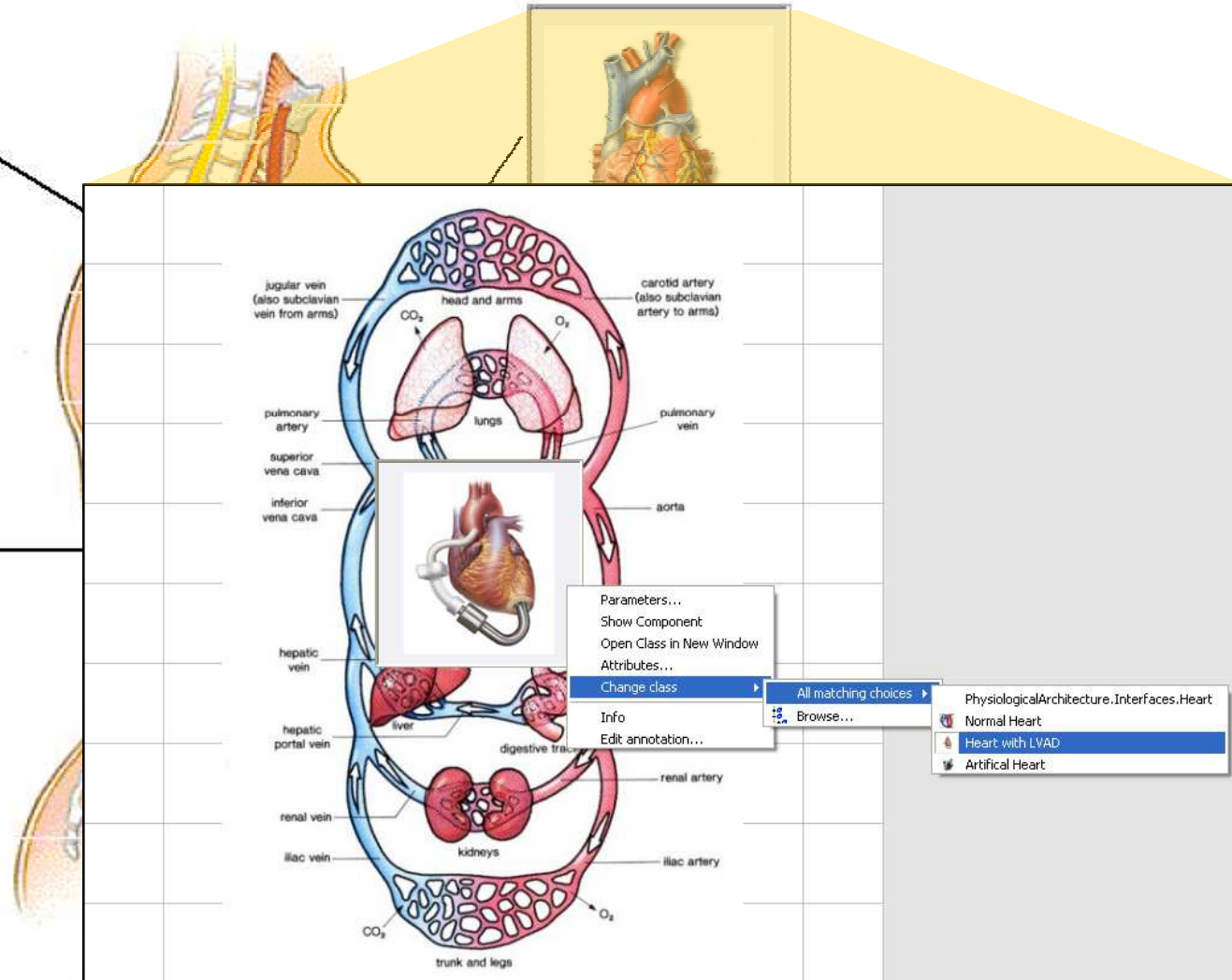
Physiological Architecture



respiratory_system



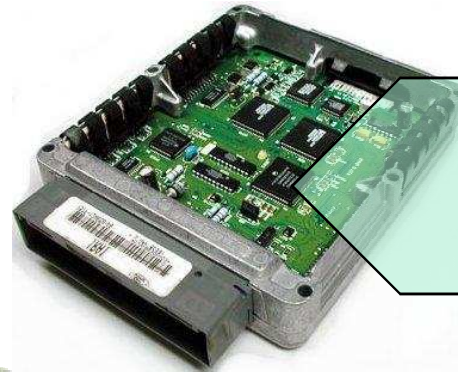
kidney



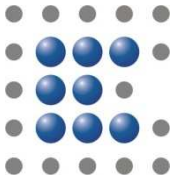


“Observers”

- When you cannot measure something...
- Diagnostics
- Prognostics

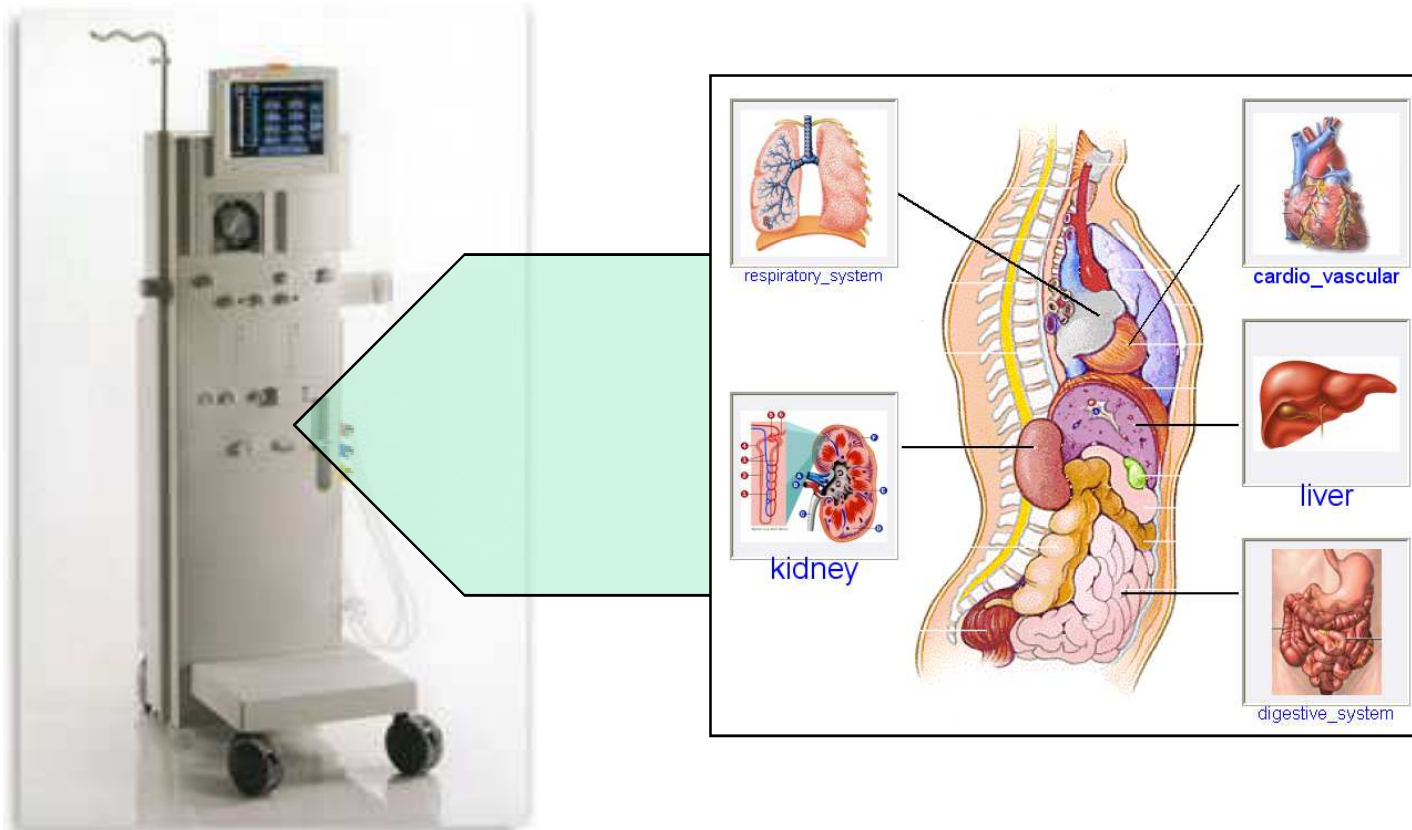


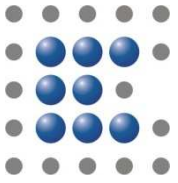
Models are an important aspect of automated control



“Observers”

- When you cannot measure something...
- Diagnostics
- Prognostics





Testing Philosophy

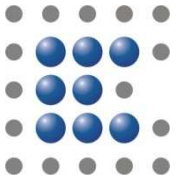
- Models are essential for testing automation
- What do you think it means to “test” something?
- Regulations \neq Quality
 - Avoiding a disaster is not the same as achieving an optimal result
 - You can't improve something you can measure



Example: State v. Chun

- Draeger Alcotest 7110 MKIII-C
 - Used in NJ since 2001
 - Used in AL, AZ, CA, FL, MA, MN, NY, PA
 - 8000 first-time convictions stayed
- Audit Findings
 - “19,400 potential errors”
 - “Defects In Three Out Of Five Lines Of Code”
 - “Would Not Pass U.S. Industry Standards for Software Development and Testing”
 - “Catastrophic Error Detection Is Disabled”



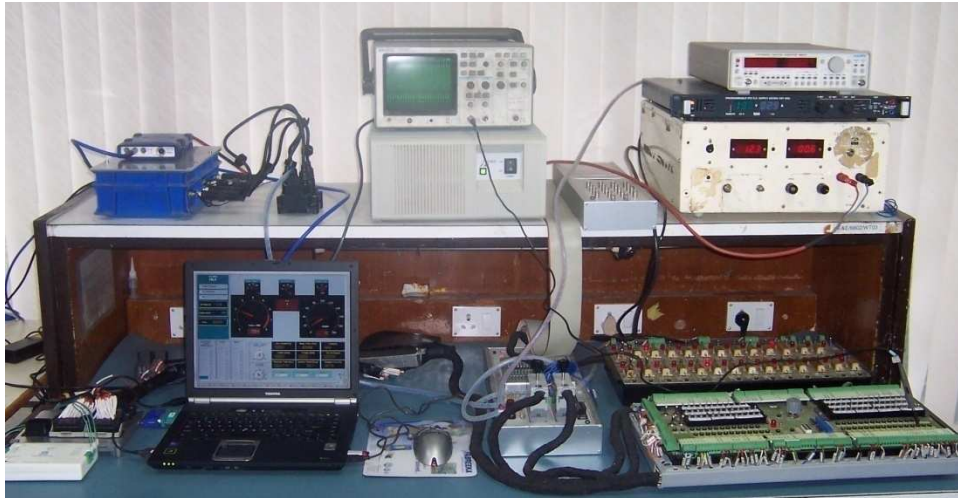


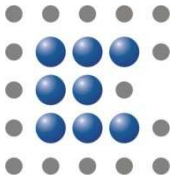
Testing Applications

- What testing means to me:
 - Confirming requirements
 - Accuracy
 - Diagnostics (failing gracefully)
 - Robustness (e.g. to patient variation, environment, other noise factors)
 - Coverage
 - Decision coverage
 - Condition coverage
 - Table coverage



Hardware-in-the-Loop





Final Thoughts

- Doctorow's Law
 - “If somebody takes something that belongs to you, locks it up and won't give you the key...they probably aren't acting in your best interest.”
- Technology is not always the limiting factor
 - Process, deployment, applications, policy
- Standards are important for scalability
 - Leverage
- Lessons to learn from CS, SE

Thanks for your time

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