Monitor Synthesis:
for software health management

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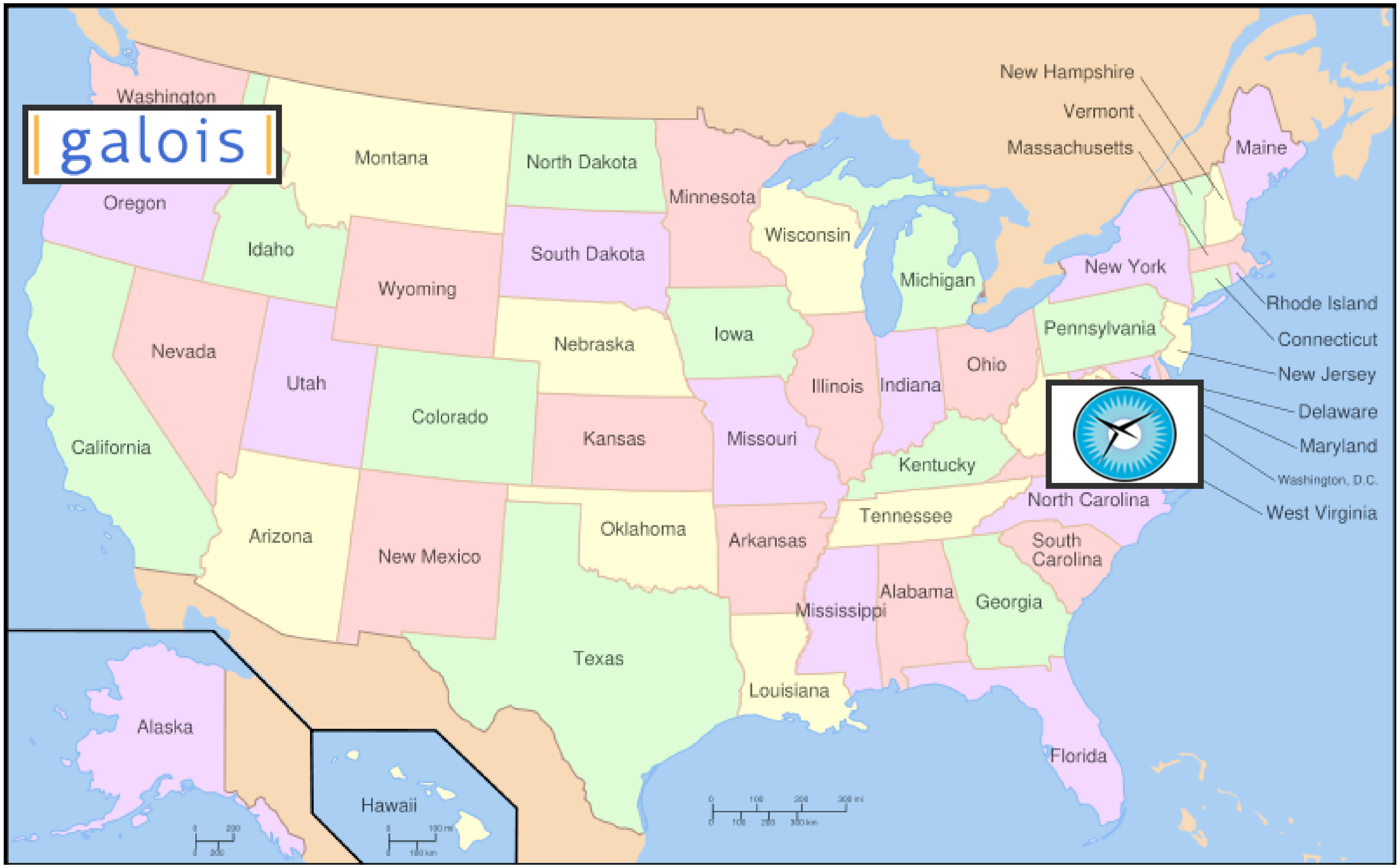
Where Are We?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Vermont
Massachusetts
Maine
Rhode Island
Connecticut
New Jersey
Delaware
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Alaska
Hawaii

Who Are We?

- Galois, Inc.
  - Galois' mission is to create trustworthiness in critical systems. We're in the business of taking blue-sky ideas and turning them into real-world technology solutions.
  - About 40 employees, including experts in functional programming, formal methods, and security.
- National Institute of Aerospace (NIA)
  - NIA is a non-profit research and graduate education institute created to conduct leading-edge aerospace and atmospheric research and develop new technologies for the nation.
  - Includes the NIA Formal Methods Group, working on critical systems of interest to NASA.

Project Staff

- Lee Pike, Galois (PI)
- César Muñoz, NIA (Co-PI)
- Alwyn Goodloe, NIA (Research Scientist)

- Consultants:
  - Joe Hurd, Galois
  - John Matthews, Galois

Software Health Management

- What is software health for embedded control systems?
  - Functional correctness
  - Timing properties
  - Safety properties (capturing fault-tolerance)

  Under the environmental assumptions.

- Problem:
  - testing cannot ensure the absence of errors in ultra-reliable systems,
  - and formal proof does not yet scale.

- So “who watches the watchmen?”

…

Software Monitoring

- *Simplicity is the unavoidable price which we must pay for reliability.* —C.A.R. Hoare
- Simple monitors analyze executions at runtime for software health.
- Monitors raise alarms or attempt to reset the system (into a known safe state).
- **Research question**: can software monitoring form a basis of software health management?

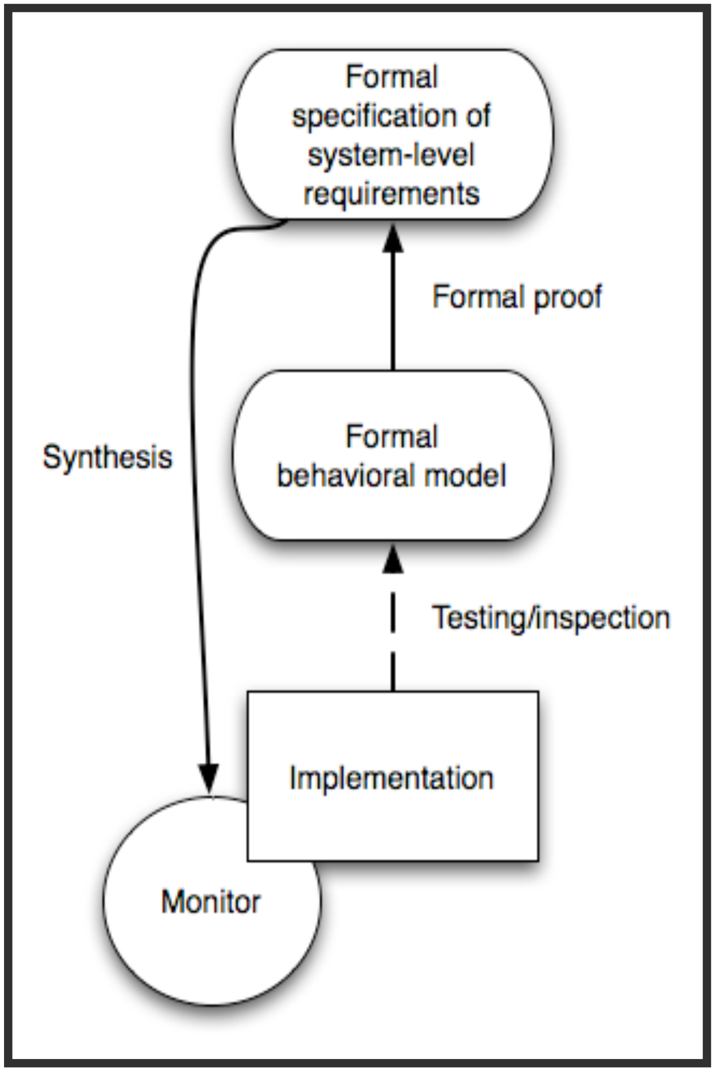
Research Contributions to IVHM

- **Our research hypothesis:** we can synthesize software monitors for *ultra-reliable systems* that are distributed, fault-tolerant, hard real-time.

- **Our research challenges:**
  - Distributed systems may require distributed monitoring (diagnosis without global information).
  - Monitors should not jeopardize hard real-time requirements of the monitored systems.
  - Monitors *themselves* need to be reliable, perhaps requiring fault-tolerance.
  - Formally synthesizing these monitors from requirements.

Key Research Contributions

- **Approach:**
  - Formal synthesis of fault-tolerant monitors from system specifications.
- **Systems characterization:**
  - Hard real-time
  - Fault-tolerant
  - “Small graphs”
  - “Fixed topology”
- **Properties to monitor:**
  - Validity
  - Agreement
  - Timing constraints



Proposed Monitoring Case Studies

- NASA’s *SPIDER* (Scalable Process-Independent Design for Enhanced Reliability)
  - An ultra-reliable databus designed and prototyped by the NASA Langley Safety-Critical Avionics Systems Branch.
  - Formally specified and verified fault-tolerant protocols.

- TTech’s *TTEthernet*
  - Allows hard real-time communication and services over ethernet.
  - Formally specified properties.

Proposed Plan of Work

- Year 1
  - Survey state-of-the-art approaches to software health management.
  - Research monitors for hard real-time temporal constraints.
  - Research synthesis framework.
- Year 2
  - Develop synthesis framework.
  - Design monitors for timing properties, agreement, and validity for our case studies.
- Year 3
  - Develop monitors for our case studies.
  - Research the synthesis of fault-tolerant monitors.