HDCC, NASA Ames, FM group report; 12 January 2001

Formal Methods: Modeling, Specification, Verification

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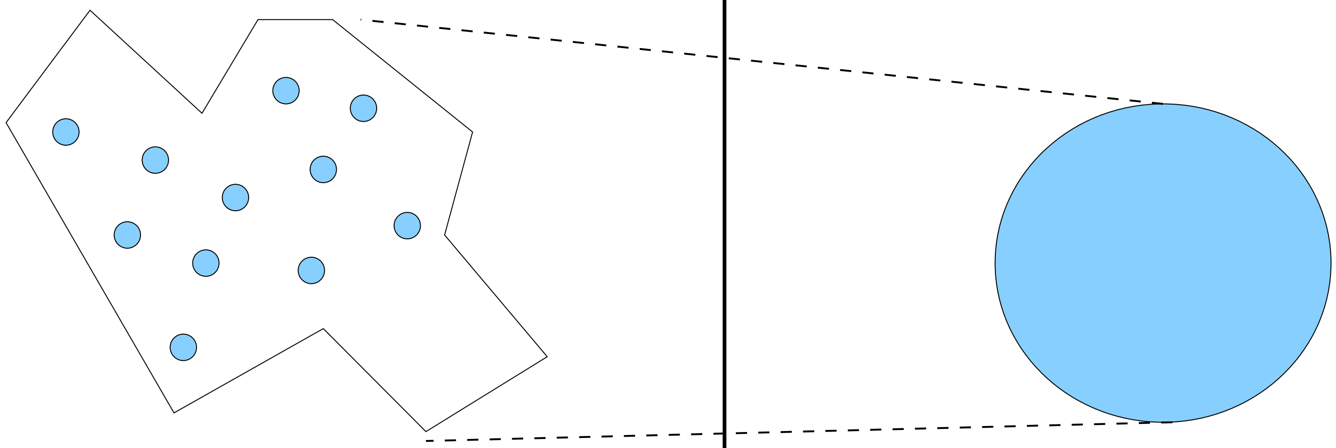
Group Report

HDCC, NASA Ames, 12 January 2001

Formal Analysis: The Idea

Testing/Simulation	Formal Analysis



Real System

Formal Model

- Partial coverage

- Complete coverage (of the modeled system)

  Accurate model: verification

  Approximate model:debugging

State of the Practice

Verification: Modest success

- FP units: Intel, AMD, Motorola
- Nuclear shutdown: Ontario Hydro
- Crypto processor: NSA/Motorola
- Avionics: Aerospatiale, Collins/NASA
- Railroads: Stålmarck, GEC/Alsthom

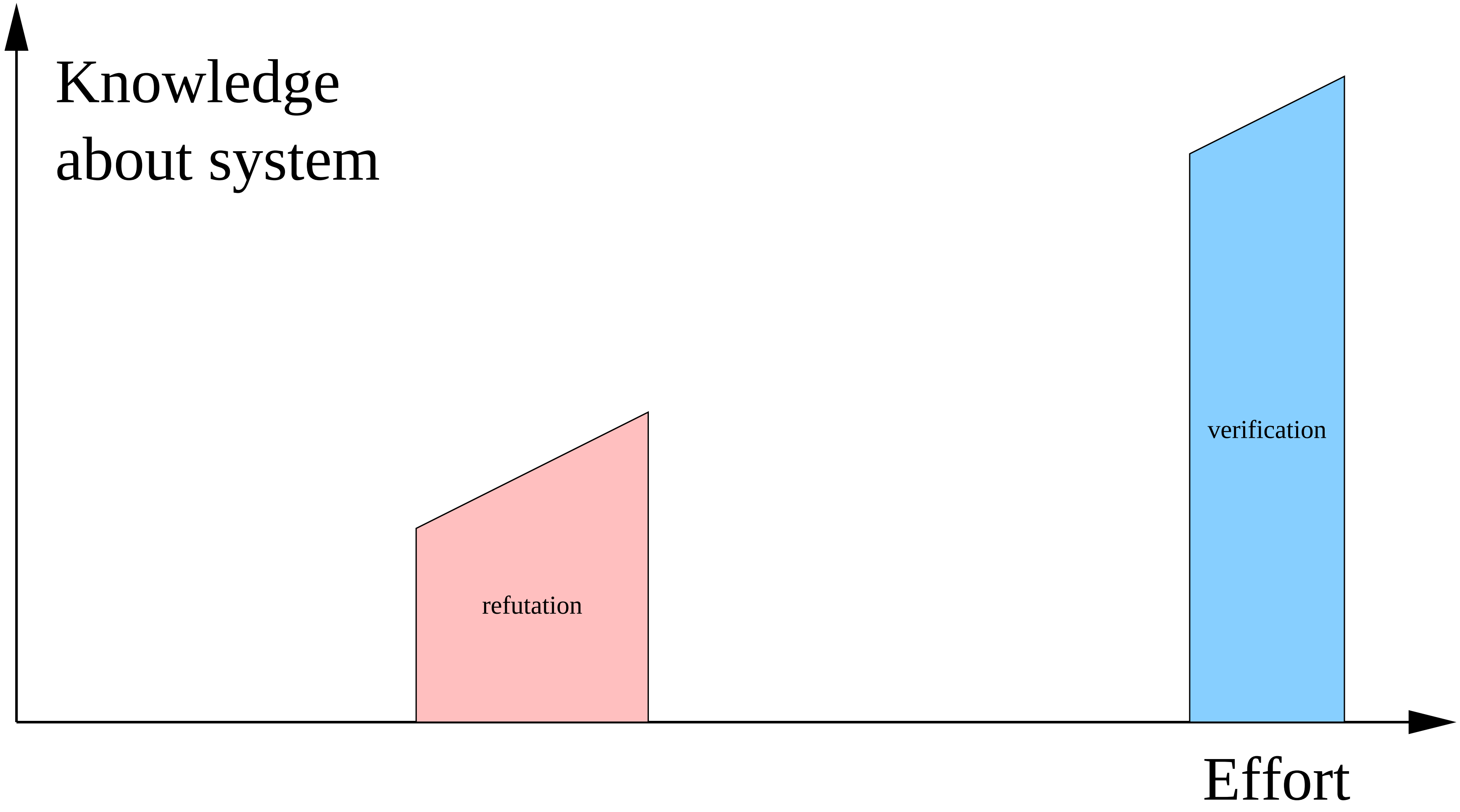
Refutation (debugging): Larger success

- Hardware (incl. equivalence checking)
- Protocols
- Statecharts
- Avionics: Honeywell/NASA

Why Were Those Applications Successful?

- Not too difficult to extract/construct the formal models
  - Mathematical domain (hardware)
  - Someone else had introduced a halfway decent notation and design method (Statecharts)
- Can get good payoff with existing tools
  - Relatively small systems
  - Other methods don't work well
    (intricate, critical systems)
  - Faults have high cost

Summary (now)



Near-Term Progress

Reducing the modelization gap (invisible formal methods)

- Extract models automatically from existing notations
  - C++ (Verisoft)
  - Java (JPF, Bandera)
  - Machine code (SLAM)
- Analyze weaker properties
  - Stronger typechecking (ESC, Lackwit)
  - Static analysis (Prefix, Logiscope)
- Build languages around architectural frameworks (APIs of well-designed middleware)
  - TTA (Giotto)
  - Publish/Subscribe

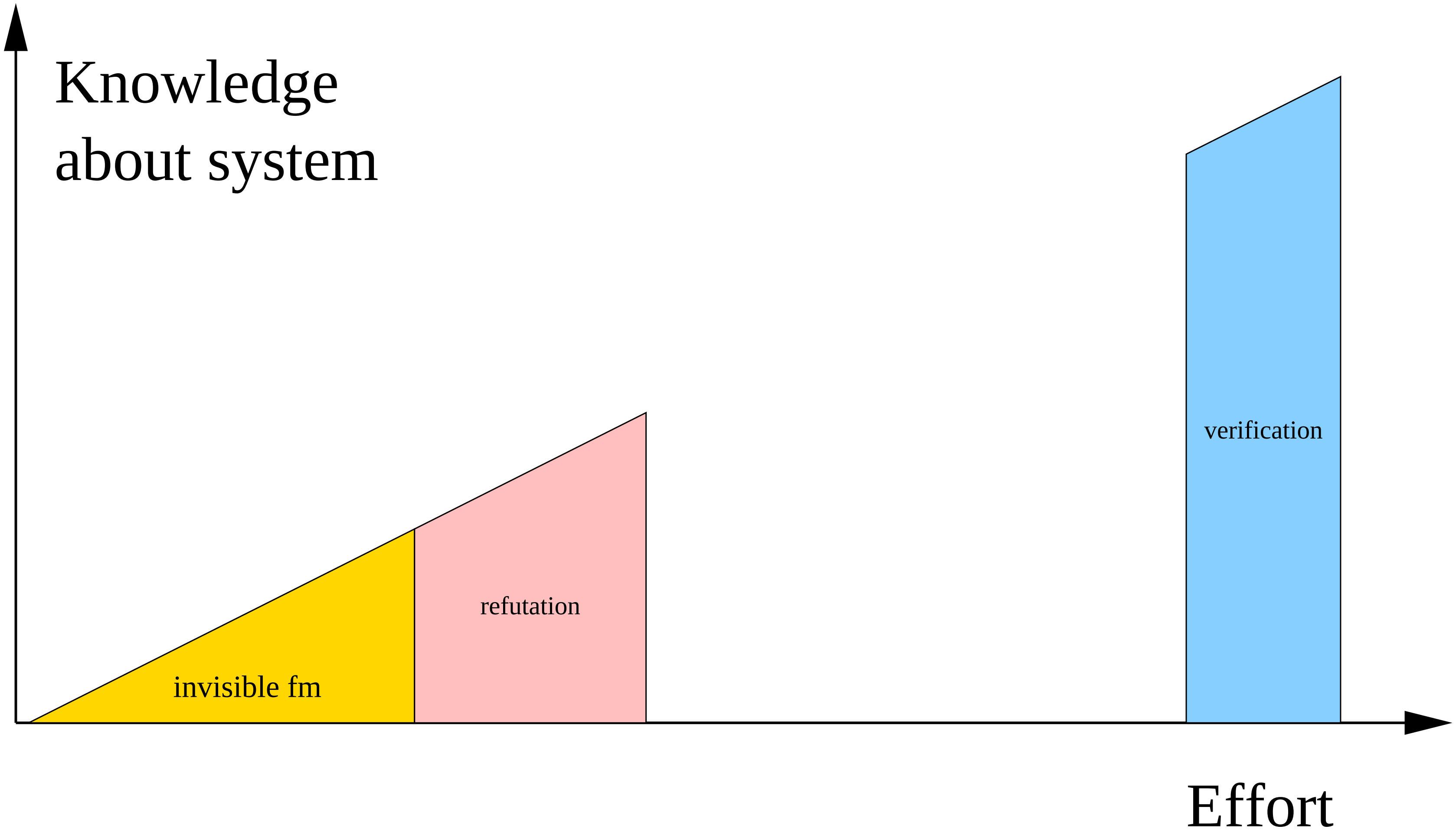
Near-Term Progress (ctd)

Better/different analysis

- Analyze different properties, for different purposes
  - Human factors (mental models)
  - Data, rather than control (Alloy)
  - Test case generation (TGV, UTwente)
  - Computer algebra systems
- Use more powerful analysis

  (don't have to simplify the models so much)
  - Infinite state-model checking
  - Hybrid systems
  - Automated abstraction
  - More automated theorem proving

Summary (Near-Term)



Near-Term Challenges

- Get involved in design of emerging industry-accepted notations to make them more amenable to effective analysis
  - UML (OCL)
  - System design languages
- Similarly for frameworks
- Build more powerful tools

Long-Term Challenges

- Cf. Challenge problems
- Dependability is often concerned with nonfunctional properties (security, partitioning, reliability)
- Undependability usually arises through unanticipated interactions among components
    - Or the system and its environment
- Will be concerned with large systems, often using COTS components, and nontraditional software (neural nets, learning)
- Formal methods must confront these realities

Long-Term Prospects

- Get basic technology into the mainstream:

  pervasive formal methods

  - Education
  - Tech transfer
    - ⋆ Eliminate 10% of testers (economic argument)
    - ⋆ Make same number more productive (dependability)

- Develop technology for the more challenging applications
  - Compositional design and verification
  - Runtime verification?
  - Smooth tradeoff between effort and return

Summary (Long-Term)