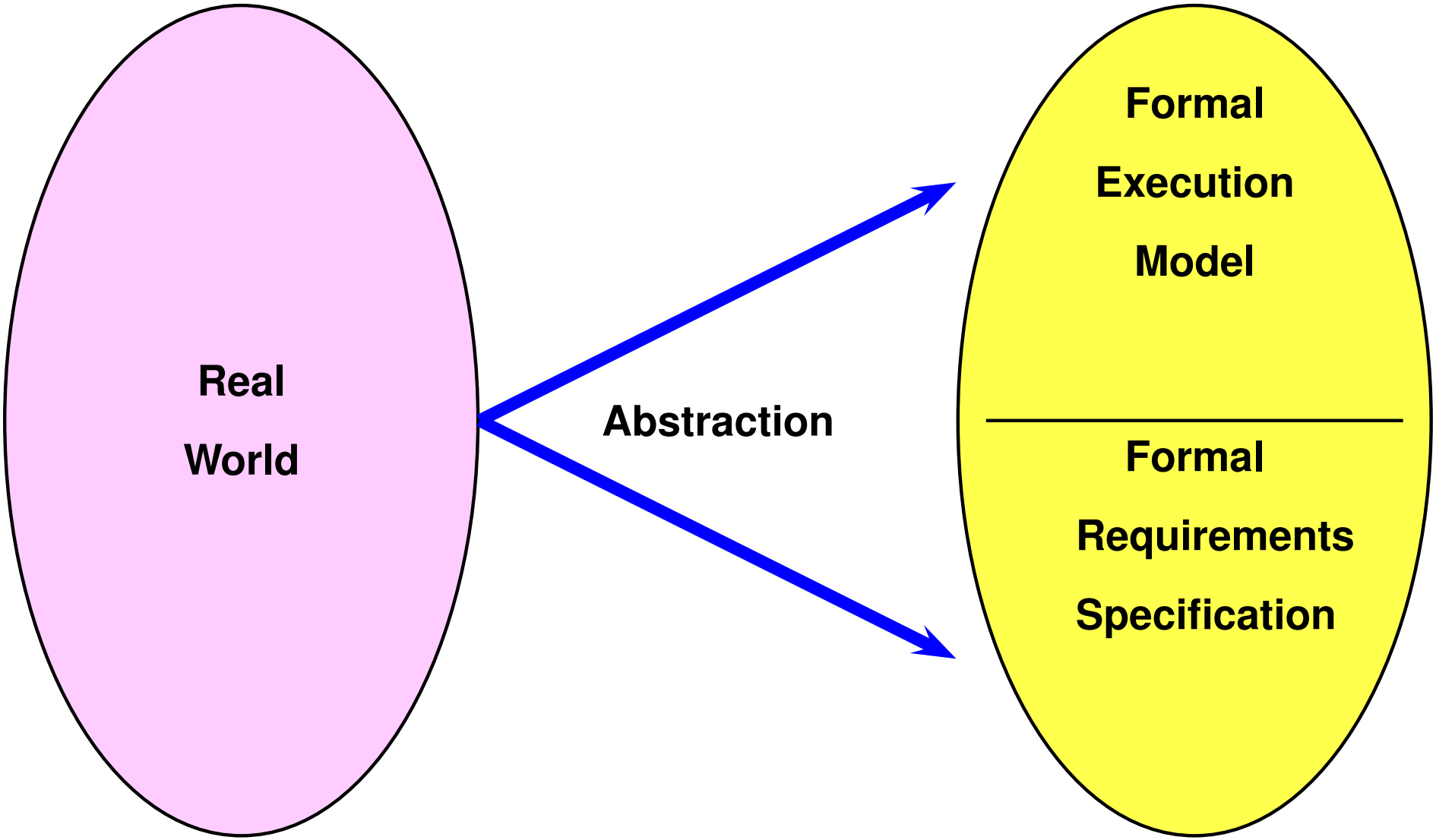
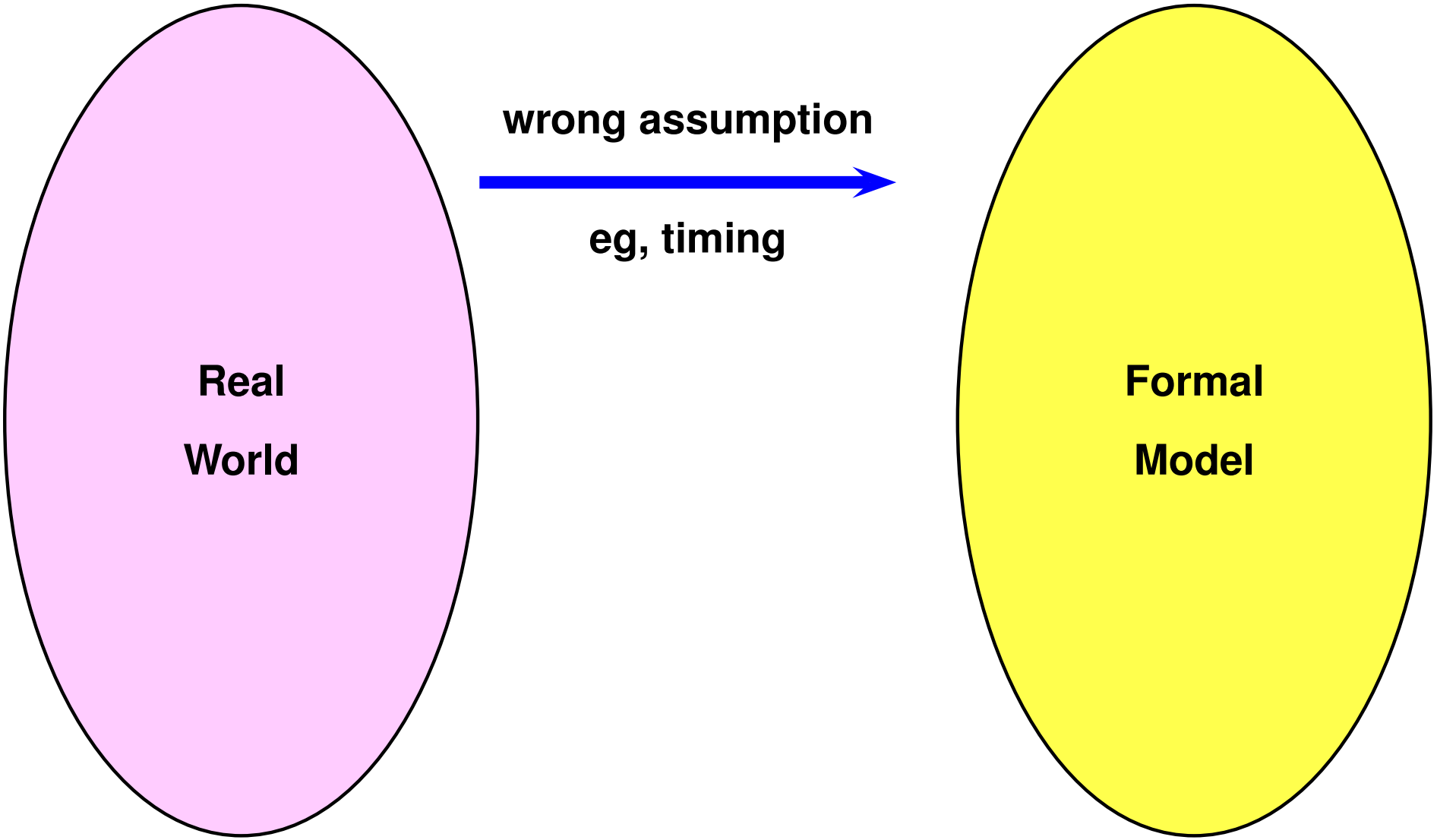
A Fundamental Fact

Formalisation of system requirements is hard

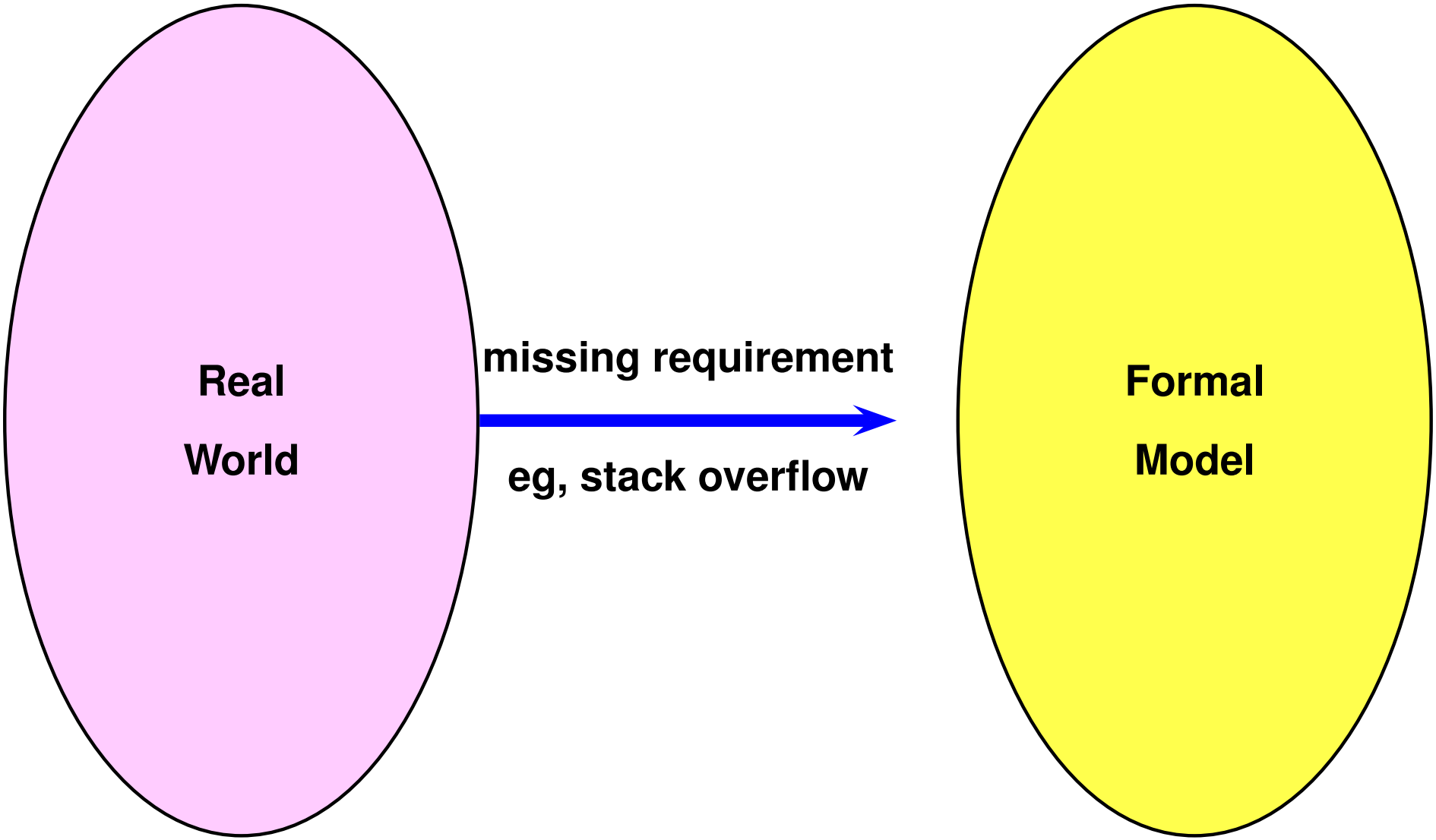
Difficulties in Creating Formal Models



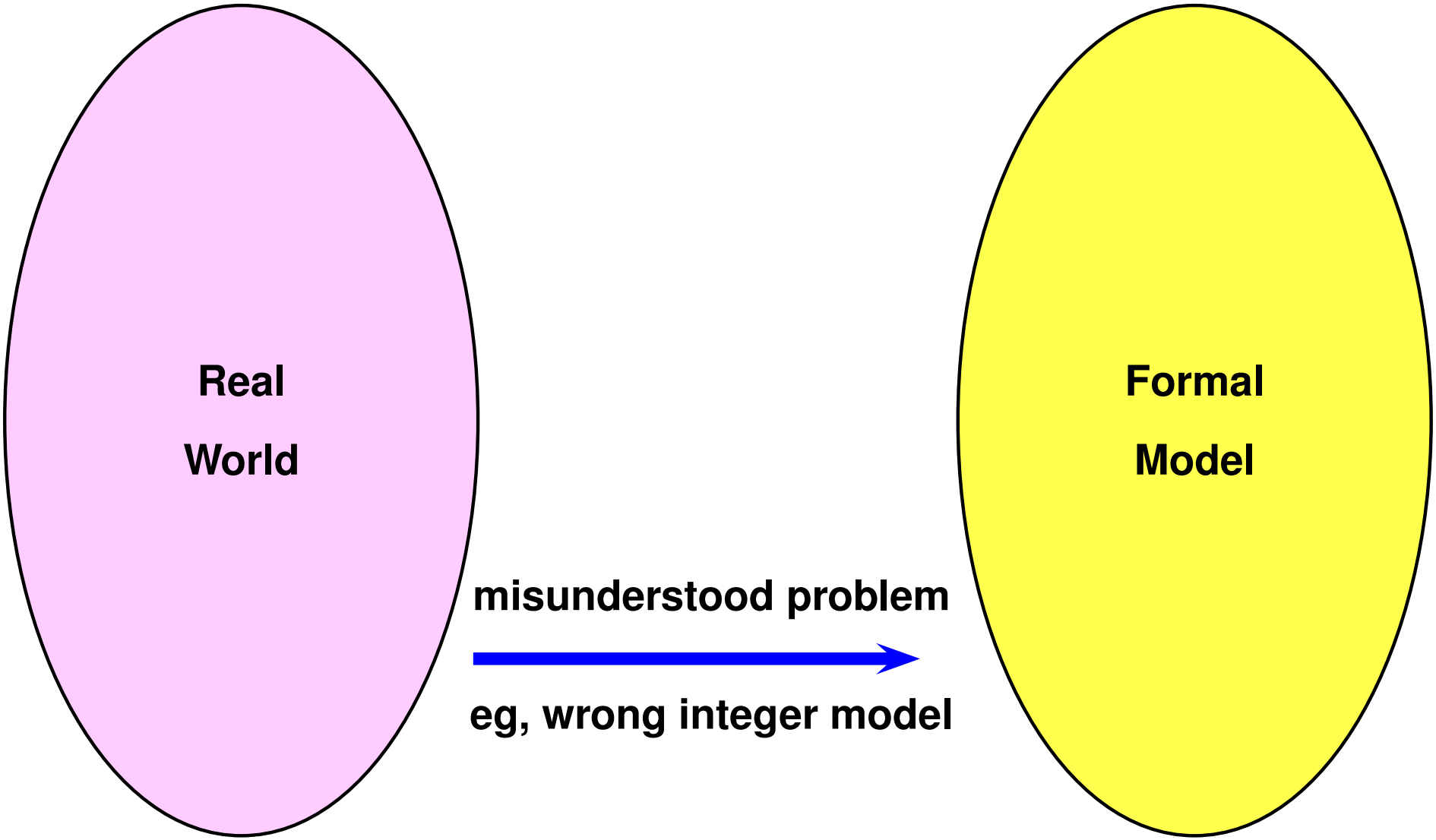
Difficulties in Creating Formal Models



Difficulties in Creating Formal Models



Difficulties in Creating Formal Models

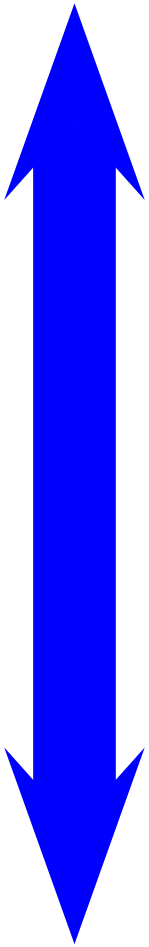


Another Fundamental Fact

Proving properties of systems can be hard

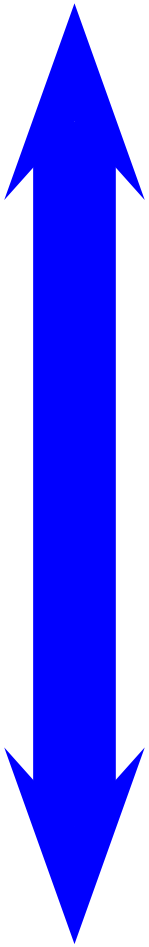
System Abstraction Level

- Low level of abstraction
  - Finitely many states
  - Tedious to program, worse to maintain
  - Automatic proofs are (in principle) possible
- High level of abstraction
  - Complex datatypes and control structures
  - Easier to program
  - Automatic proofs (in general) impossible!



Specification Abstraction Level

- Low level of abstraction
  - Finitely many cases
  - Approximation, low precision
  - Automatic proofs are (in principle) possible
- High level of abstraction
  - General properties
  - High precision, tight modeling
  - Automatic proofs (in general) impossible!

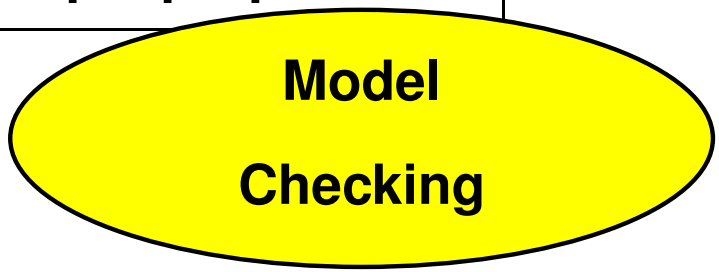


Main Approaches

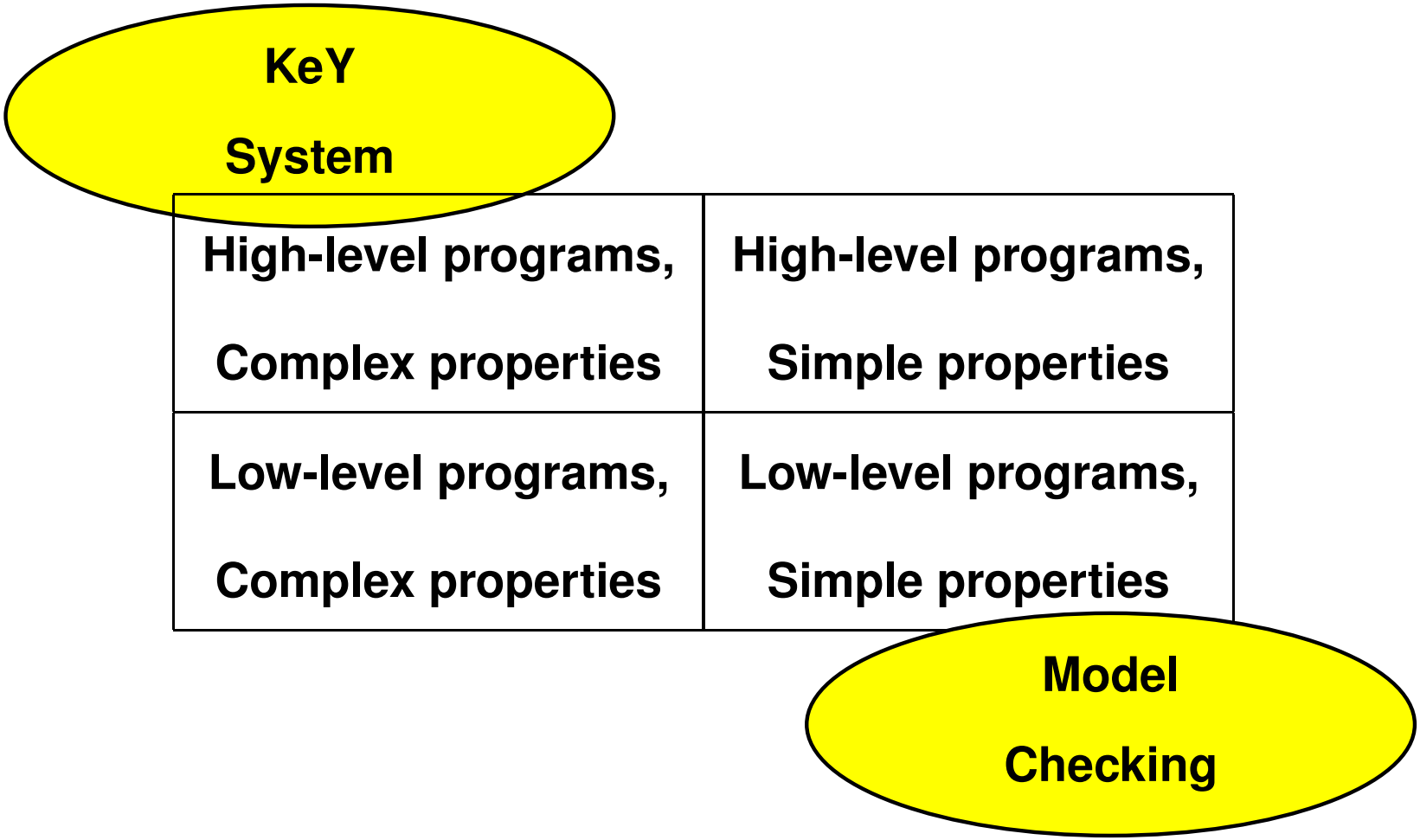
High-level programs, Complex properties	**High-level programs, Simple properties**
Low-level programs, Complex properties	**Low-level programs, Simple properties**

Main Approaches

High-level programs, Complex properties	High-level programs, Simple properties
Low-level programs, Complex properties	Low-level programs, Simple properties

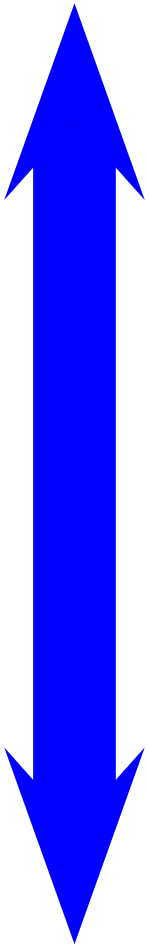


Main Approaches



Proof Automation

- “Automatic” Proof
  - No interaction
  - Sometimes help is required anyway
  - Formal specification still “by hand”
- “Semi-Automatic” Proof
  - Interaction may be required
  - Very often proof tool suggests proof rules
  - Proof is checked by tool



SPIN at Bell Labs

Feature interaction for telephone call processing software

- Tool works directly on C source code
- Web interface to track properties
- Work farmed out to large numbers of computers
- Finds shortest possible error trace
- 18 months, 300 versions, 75 bugs found
- Main burden: Defining meaningful properties

SLAM at Microsoft

- Device drivers running in “kernel mode” should respect API
- Third-party device drivers that do not respect APIs responsible for 90% of Windows crashes
- SLAM inspects C code, builds a finite state machine, checks requirements
- Being turned into a commercial tool right now

Future Trends

- Design for formal verification
- Combining automatic methods with theorem provers
- Combining static analysis of programs
  with automatic methods and with theorem provers
- Combining test and formal verification
- Integration of formal methods into SW development process
- Integration of formal method tools into CASE tools

Formal Methods

- Are (more and more) used in practice
- Can shorten development time
- Can push the limits of feasible complexity
- Can increase product quality

Formal Methods

- Are (more and more) used in practice
- Can shorten development time
- Can push the limits of feasible complexity
- Can increase product quality

Those responsible for software management should consider formal methods, in particular, where safety-critical, security-critical, and cost-intensive software is concerned