UPPAAL in Teaching

ASTEC Project

Paul Pettersson

paupet@it.uu.se

ASTEC
Advanced Software Technology

UPPSALA UNIVERSITET

Information Technology

Paul Pettersson

PhD student at Uppsala University supported by ASTEC

1994

Post Doc. at Aalborg University

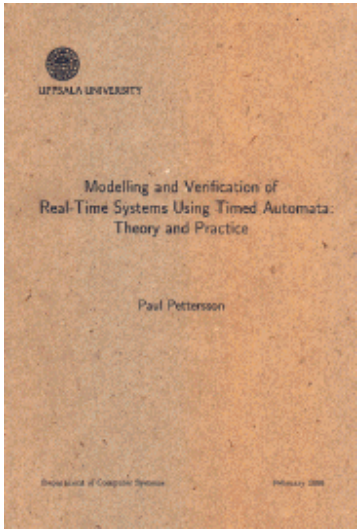
1999

Senior Lecturer at Uppsala University

2000

2002

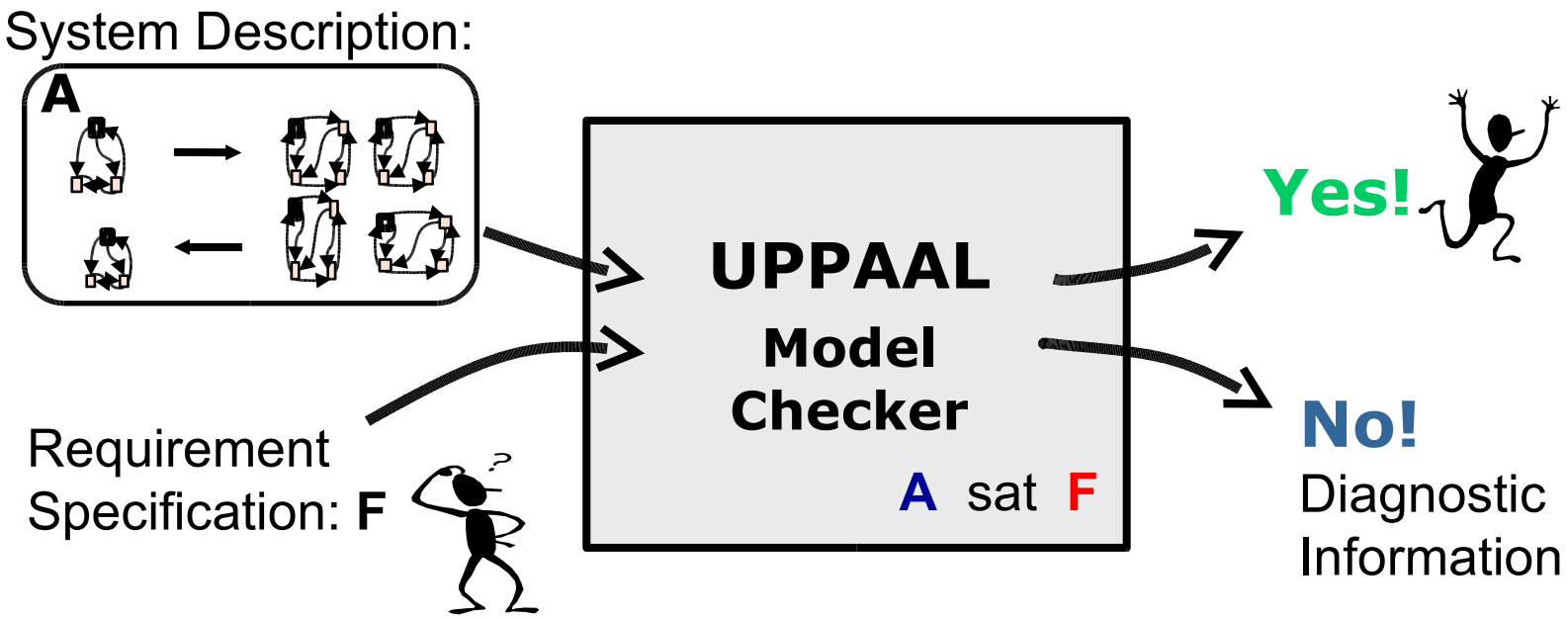
Project Leader of ASTEC Automated Testing Project



ASTEC Advanced Software Technology

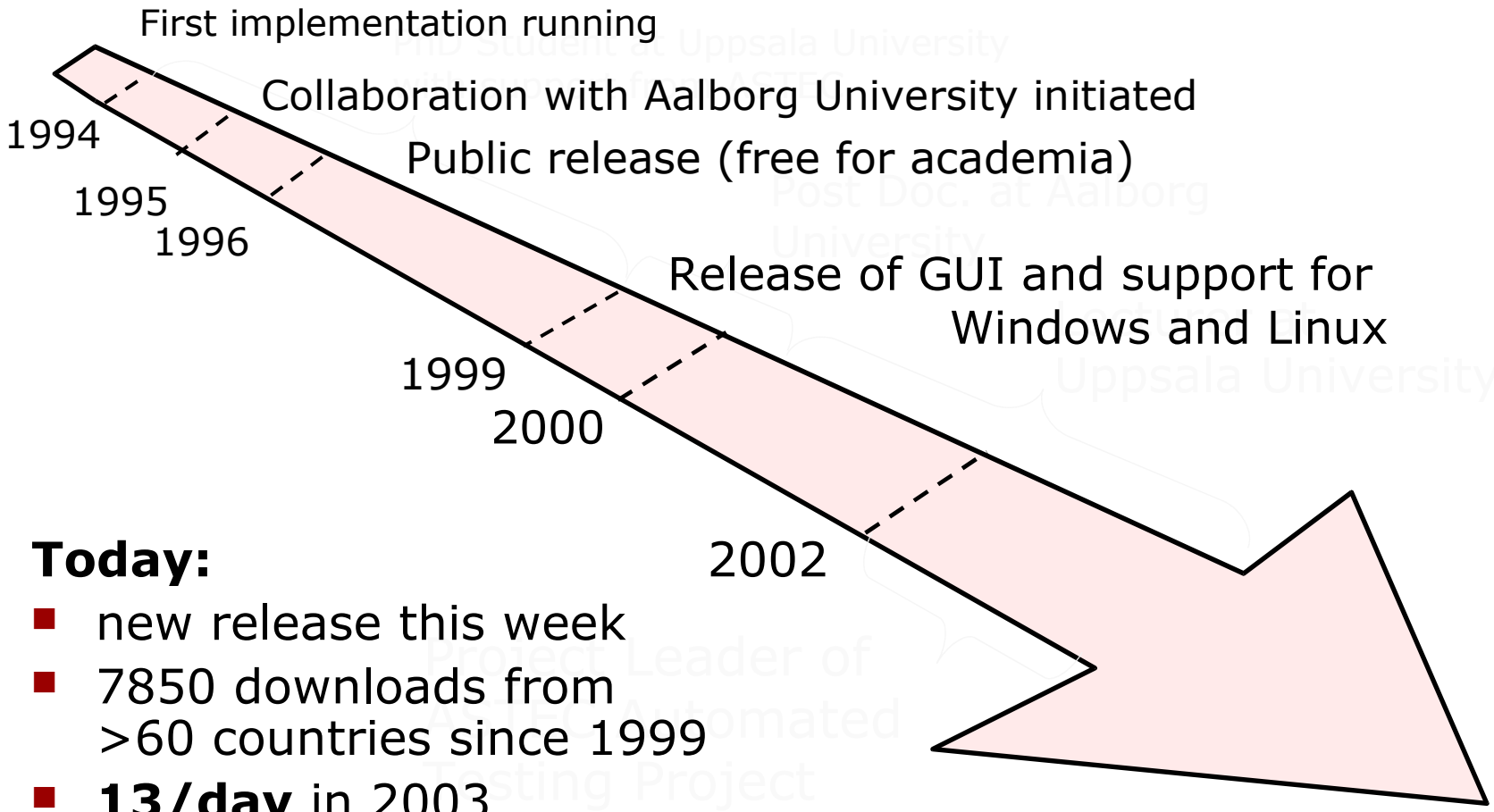
UPPAAL

- Modeling and verification of real-time systems



- Timed automata + temporal logical formula
- Model-checking
- Simulation, debugging, code-generation (in Times)

UPPAAL Development



Today:

- new release this week
- 7850 downloads from >60 countries since 1999
- **13/day** in 2003
- used in universities and industry

ASTEC Advanced Software Technology

Teaching with UPPAAL World-Wide

- Real-Time Systems, Aalborg, Denmark, -2003
- Real-Time Systems, **DTU**, Denmark, 2002-2003
- Practical course in real-time systems, **Oldenburg**, Germany, 2000-2001
- System Validation (using Model Checking), **Twente**, The Netherlands, 2003
- Protocol Validation, **Nijmegen**, The Netherlands, 2002-2003
- Analysis and Verification of Hard Real Time Systems, **NUS**, Singapore, 2003.
- Real-Time programming, Nohau, Sweden, 2003
- Verification, **IIS**, India, 2003
- Model Checking, **Chalmers**, Sweden, 1999.
- Hybird Systems, **UPenn**, USA, 2003.
- Control of Discrete-Event Systems, **CWI**, The Netherlands, 1999.
- **Marktoberdorf** Summer school, 2002.
- **Durham**,
- …
- …and at Uppsala University

ASTEC Advanced Software Technology

Under graduate level courses

- **Process algebra**, since 1997
  - 20 students/year, 3-4 credit points, Uppsala Univ.
    - 4th year computer engineering/science
  - preparation lecture on UPPAAL
  - laboratory assignment with UPPAAL
    - modeling and analysis of a protocol
    - simulation, debugging, formalizing requirement, model-checking
- **Real-time systems**, since 1999
  - 150 students/year, 5 credit points, Uppsala Univ.
    - 4th year computer engineering/science, information engineering
  - four lectures on timed automata technology
  - laboratory assignments with UPPAAL
    - modeling and analysis of: real-time protocols, scheduling problems, control algorithms

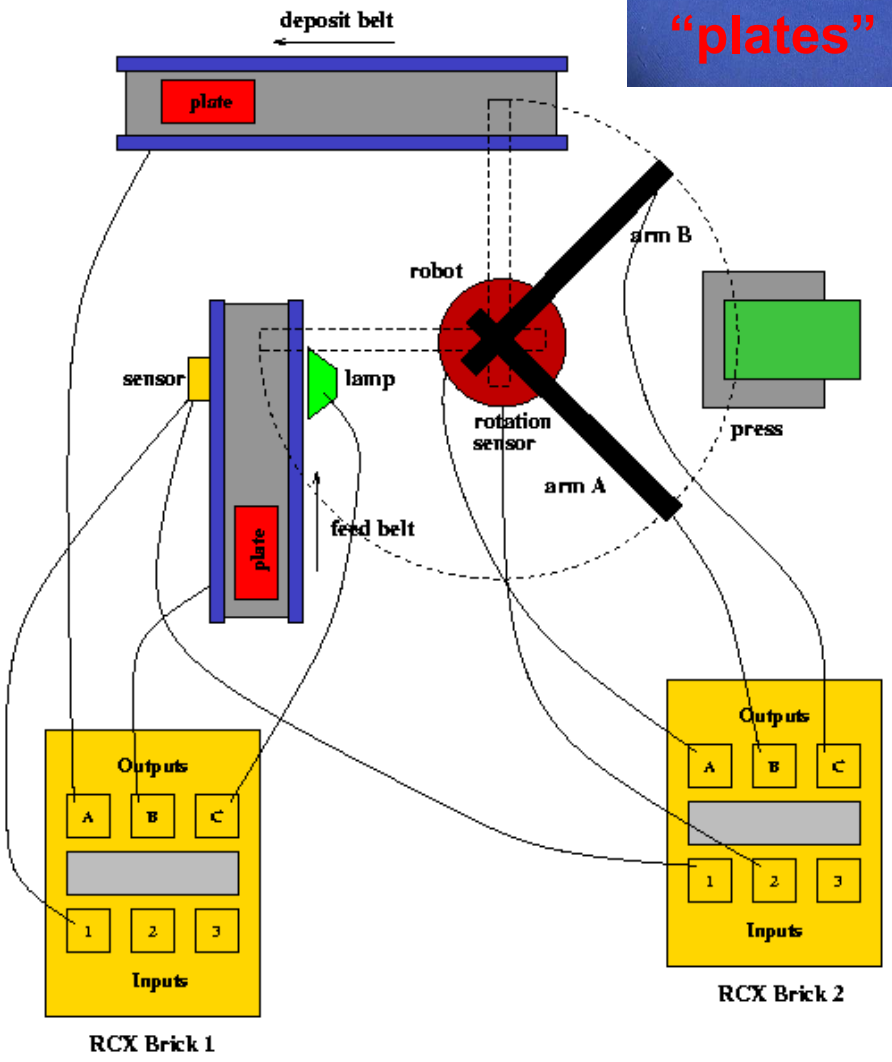
ASTEC Advanced Software Technology

Under graduate level (cont.)

- **Real-time systems**, since 2000
  - 40 students/year, 5 credit points, DTU, Denmark.
    - 4th year computer engineering/science
  - 8 lectures:
    - Finite automata, CTL, model-checking algorithms
    - Timed automata, TCTL, model-checking algorithms, data structures, time/space reduction techniques
    - UPPAAL, modeling language, modeling tricks (how to model/specify X),
    - Applications, Case-Studies, and State-of-the-Art
  - 8 sets of laboratory assignment
    - modeling and analysis of: real-time protocols, scheduling problems, control algorithms
  - 1 project (2 weeks work)
    - model, analyze, and generate code for a production cell

LEGO Production Cell

- Realistic case-study described in literature with several formalisms (1994 and later).
- Objective: stamp metal plates in press.
- Feed belt, two-armed robot, press, and deposit belt
- Physical version built in LEGO
- Students are asked to model-based develop control program:
  - model,
  - simulate,
  - verify,
  - transform to C-code



Graduate Level Courses with UPPAAL

- Modeling and analysis of real-time systems ARTES, Uppsala, Sweden, 1997.
- Formalisms, algorithms and tools in formal methods for real-time, ARTES, MdH and Uppsala, Sweden, 2002.
- Real-time and embedded systems, CUGS, Sweden, 2002-2004.
- Modeling and analysis of real-time systems using UPPAAL, Skövde, Sweden, 2002.

- Real-time systems and scheduling, ESSES Summer school, MdH, Oct 2003.

Teaching with UPPAAL World-Wide

- Process Algebra, Uppsala, Sweden 1997-2003
- Real-Time Systems, Uppsala, Sweden, 1999-2003
- Real-Time Systems, Aalborg, Denmark, -2003
- Real-Time Systems, DTU, Denmark, 2000-2001
- Modeling and analysis of real-time systems Uppsala, Sweden, 1997.
- Formalisms, algorithms and tools in formal methods for real-time, MdH and Uppsala, Sweden, 2002.
- Real-time and embedded systems, CUGS, Sweden, 2002-2003.
- Modeling and analysis of real-time systems using UPPAAL, Skövde, Sweden, 2002.
- Real-time systems and scheduling, ESSES Summer school, MdH, 2003.
- Real-Time Systems, **DTU**, Denmark, 2002-2003
- Practical course in real-time systems, **Oldenburg**, Germany, 2000-2001
- System Validation (using Model Checking), **Twente**, The Netherlands, 2003
- Protocol Validation, **Nijmegen**, The Netherlands, 2002-2003
- Analysis and Verification of Hard Real Time Systems, **NUS**, Singapore, 2003.
- Real-Time programming, Nohau, Sweden, 2003
- Verification, **IIS**, India, 2003
- Model Checking, **Chalmers**, Sweden, 1999.
- Hybird Systems, **UPenn**, USA, 2003.
- Control of Discrete-Event Systems, **CWI**, The Netherlands, 1999.
- **Marktoberdorf** Summer school, 2002.
- **Durham**,
- …

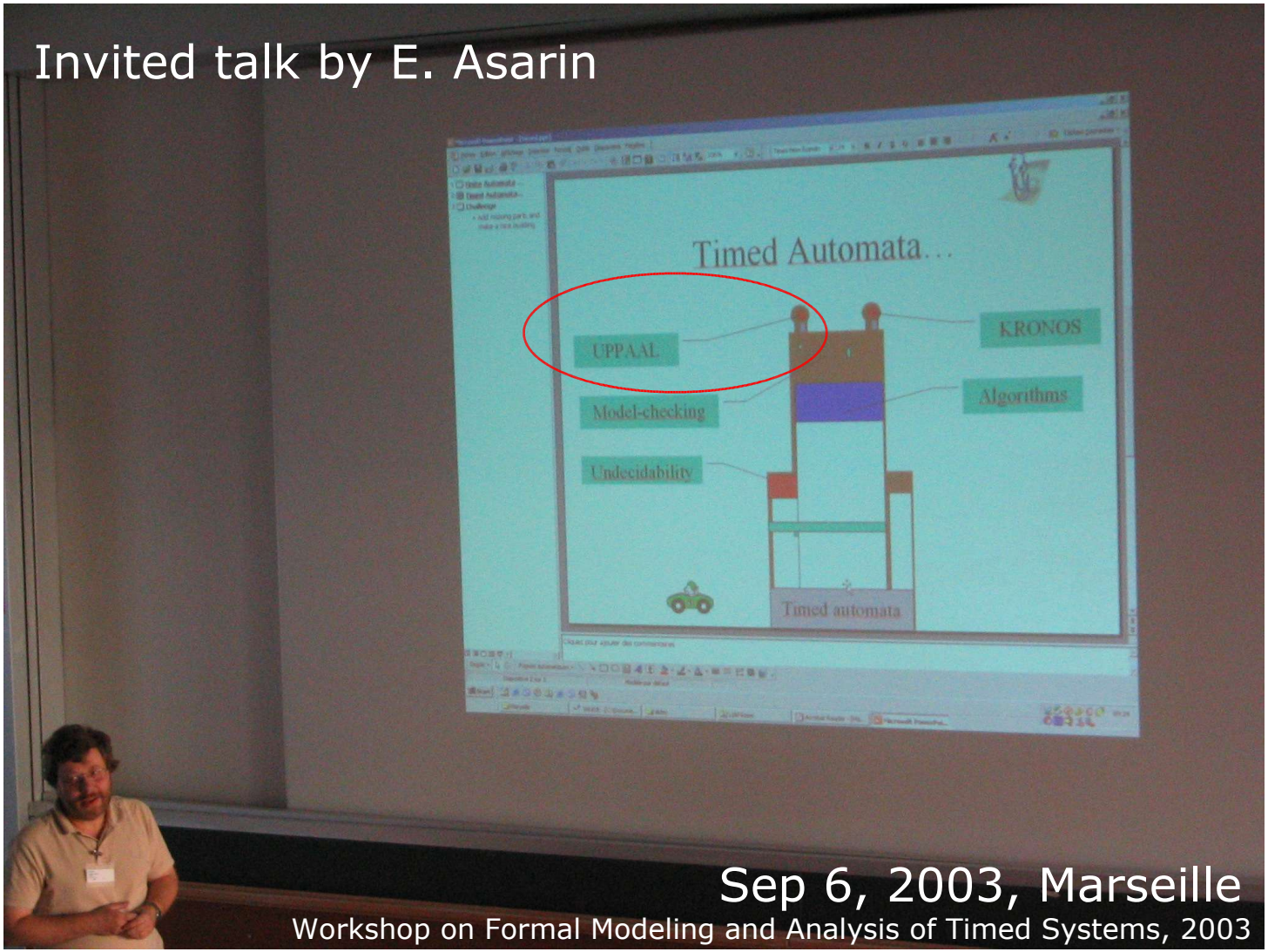
HOW?

ASTEC
Advanced Software Technology

UPPSALA UNIVERSITET

Information Technology

UPPAAL in Research Community



ASTEC Advanced Software Technology

UPPSALA UNIVERSITET

Information Technology

Learning with UPPAAL

- model-based development
  - modeling – syntax, data structures, composition
  - simulation – semantics, validation
  - verification - model-checking, state space explorations, effect of optimizations
  - code synthesis (with Times)
- timed automata techniques/technology
- timing (real-time phenomena, real-time protocols, controllers, scheduling)

ASTEC Advanced Software Technology

Teaching support

- **course material:**
  - 8 lectures in Powerpoint (2hrs)
  - 8 sets of laboratory assignments (3hrs)
  - 3 project assignments
  - UPPAAL
  - UPPAAL in a Nutshell + tutorial
- **books:**
  - Concepts, Algorithms and Tools for Model-Checking, Joost-Pieter Katoen
    - Spin and UPPAAL
  - Systems and Software Verification – Model-checking techniques and tools, LSV, Springer-Verlag
    - Identifies six important tools
    - Chapter on UPPAAL