TUHH
Hamburg University of Technology

Institute of Embedded Systems

Compilers for Embedded Systems

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Chapter 1

Introduction & Motivation

Embedded Systems

Definition: Embedded Systems (ES) are
- information-processing systems
- that are embedded into a larger, surrounding product.

- The fact that embedded systems process information is not decisive for a purchase
- Instead: Benefit of surrounding product influences purchase decision

*[**P. Marwedel.** Embedded System Design. Springer, 2011]*

Application Areas of Embedded Systems

Consumer products

Multimedia

Transportation

Telecommunication

Building management, robotics, …

Relevance of Embedded Systems

- **Smartphones** 113 m. devices 2007 ⇝ *25.6% increase p.a.*
  365 m. devices 2012
- **UMTS** 402 m. customers worldwide 2008
  30 m. new customers per quarter
- **Energy consumption of mobile broadband infrastructure**
  42.8 m. kWh 2005 ⇝ 124.4 m. kWh 2011
- **Broadband internet**
  576 m. customers 2011 ⇝ *100% increase compared to 2007*
- **US consumer electronics**
  ∅ household: 25 devices, ∅ *adult: 1,200$ p.a.*

[www.itfacts.biz]

Demands on Embedded Systems (1)

Efficiency

– Runtime efficiency

– Energy consumption

– Code size

– Physical size / weight

– Cost

Demands on Embedded Systems (2)

Real-Time Capabilities

- **Definition:** For some input *x*, a computer system computes some *f(x)*.
  - A ***Non-Real-Time System*** is correct if it computes *f(x)* correctly.
  - A ***Real-Time System*** is correct if the computation of *f(x)* completes *within given time bounds*.

☞ **A too late computation of *f(x)* by a Real-Time System is as severe as a functionally incorrect computation.**

Demands on Embedded Systems (3)

Real-Time Capabilities

– **“Hard” Real-Time System:**
Late computation of *f(x)* ↝ Catastrophic consequences
(loss of human life, environmental damages, …)

Example airbag control:
Command to ignite the airbags: 15ms
Deadline miss: Danger of injuries for passengers or saviors. Thus: Do not fire airbags

– **“Soft” Real-Time System:** No catastrophic consequences
Example DVD player:
Deadline miss during frame decoding: *Frame-Drop*
Not nice but (usually) not disastrous

Demands on Embedded Systems (4)

Dependability / Safeness

– Life span of embedded systems: Typically several years
– During the entire lifetime: No outage

– *Example throttle valve control:*

Production volume:	2 m. units per year
Allowed error rate:	1 unit per year

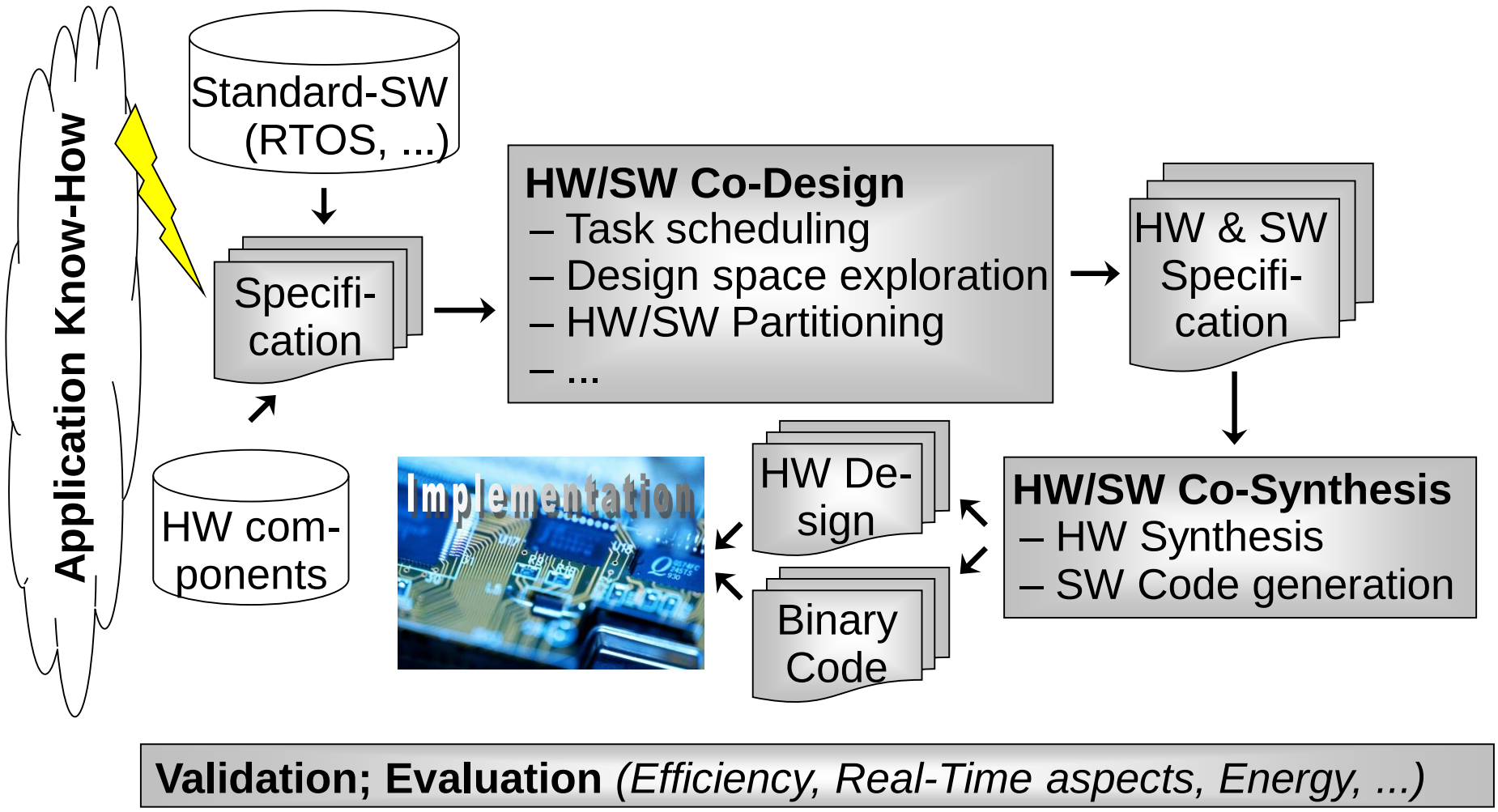
Maintainability, (Limited Extensibility)

– Error search and diagnosis, reconfiguration during runtime

Design Automation *(↝ Time to Market)*

– Specification, synthesis, code generation

Design Process of Embedded Systems



Topics of the Course

Overview

1. Introduction & Motivation
2. Compilers for Embedded Systems – Requirements & Dependencies
3. Internal Structure of Compilers
4. Pre-Pass Optimizations
5. HIR Optimizations and Transformations
6. Code Generation
7. LIR Optimizations and Transformations
8. Register Allocation
9. WCET-Aware Compilation
10. Outlook

General References

Embedded Systems

– Peter Marwedel. *Embedded System Design*. Springer, 2011.
ISBN 978-94-007-0256-1
Full-text available as e-book via TUHH library:
https://katalog.tub.tuhh.de/Record/1650607989

Compiler Construction

– Steven S. Muchnick. *Advanced Compiler Design & Implementation*. Morgan Kaufmann, 1997.
ISBN 978-1-55860-320-2
– Andrew W. Appel. *Modern compiler implementation in C*. Cambridge University Press, 2004.
ISBN 0-521-60765-5