

Real Time Embedded Systems

Introduction

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1. Hardware/software design and modelling of embedded computing systems
2. Protocols, design concepts and scheduling
3. Experience in programming of real-time systems

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The formal lectures cover a set of hardware and software aspects

- ▶ Real-time aspect: Petri net model, concurrency, arbitration, communication modelling, ACM
- ▶ Embedded design: threads, processes, scheduling, programming, setting up communication links between processes.
- ▶ ACM and architectures with Dr. Xia

Practicals develop skills and help to understand deeper theory.

- ▶ Software design – scheduler, real-time, ARM platform

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- ▶ no exams this year
- ▶ 40% presentation
- ▶ 60% written report 3000 words

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Deadline: the last Friday of the semester

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What is an embedded system?

Definition: “nearly any computing unit not used as a desktop computer” (Vanid & Givargis 2002)

- ▶ What about laptops, servers and mainframes?
- ▶ What if the desktop is used to control something, to route the network or just for Skype?

A better definition (Gupta 2002):

- ▶ employs a combination of hardware+software to perform a specific function
- ▶ is a part of a larger system that may not be a “computer”;
- ▶ works in a reactive and time-constrained environment.

General characteristics (Williams 2006)

- ▶ Latency limit
- ▶ Event-driven scheduling
- ▶ Time-driven scheduling
- ▶ Low-level programming
- ▶ SW tightly coupled to special HW
- ▶ Dedicated specialised functions
- ▶ Computer inside a control loop
- ▶ Multi-tasking
- ▶ Continuous running
- ▶ Various specific metrics: safety-critical app., security, power constraints, variability-tolerant design, etc.

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Software/hardware co-design

- ▶ Software provides features and flexibility;
- ▶ Hardware (processors, ASICs, memory, accelerators, etc.) is used for performance, fault-tolerance and security.

Example of DSP:

- ▶ DSPs
- ▶ processor cores
- ▶ memory
- ▶ application-specific codes
- ▶ analogue I/O

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[Gupta 2002]

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- ▶ processor cores
- ▶ memory
- ▶ application-specific gates
- ▶ analogue I/O

[Gupta 2002]

Common design metrics

Unit cost: fabrication cost of a single copy of the system, excluding NRE cost

NRE cost: (Non-Recurring Engineering cost) one-time monetary cost of designing the system

Total cost: $\text{NRE_cost} + \text{Unit_cost} * \text{Number_of_units}$

Per product cost: $\text{NRE_cost} / \text{Number_of_units} + \text{Unit_cost}$

Time-to-prototype: time to develop a working version

Time-to-market: time to develop a system to the point when it can be released and sold to customers

Flexibility: the ability to change the functionality of the system without incurring heavy NRE costs

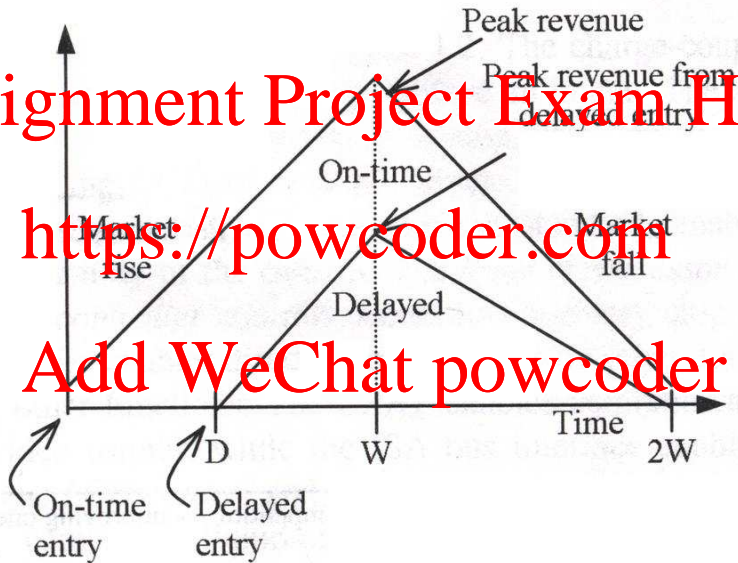
Physical metrics

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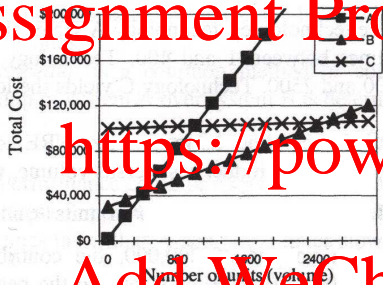
Time-to-market metric (simplified model)



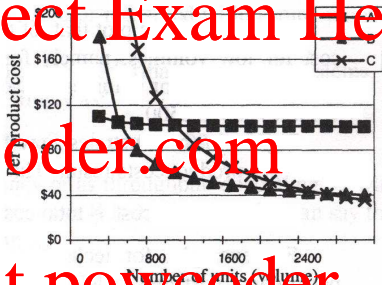
NRE and Unit Cost design metrics

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(a)



(b)

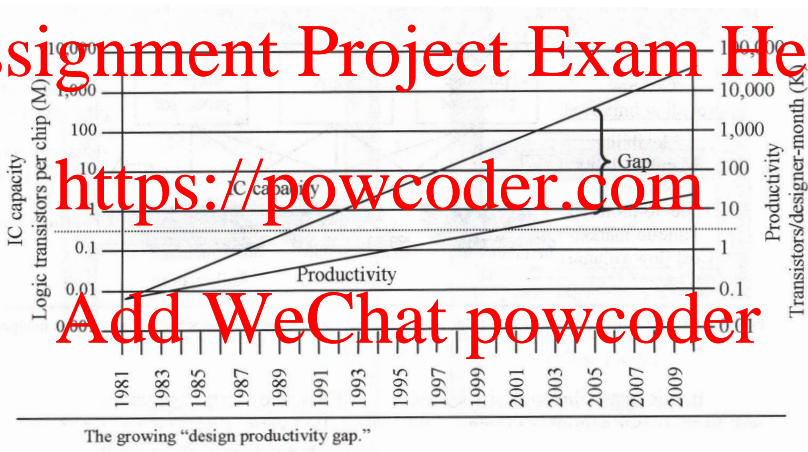
Costs for technologies A, B, and C as a function of volume: (a) total cost, (b) per-product cost.

Design productivity gap (HW)

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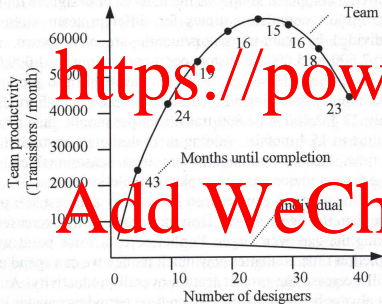


Moore's law...

The gap is bigger than it seems...

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- ▶ “The Mythical Man-Month” by Frederick Brooks 1975



- ▶ Scaling up the group “hits the wall” at some point
- ▶ After that point adding new men does NOT increase overall productivity
- ▶ Individual productivity goes down

Conclusions

- ▶ Embedded systems, including real-time, are everywhere and represent all electronic applications
- ▶ Everything above is an Introduction – the really important and complex stuff will follow
- ▶ Attendance is important
- ▶ Finding the literature sources is extremely important
- ▶ This is an advanced course – please help us to analyse your needs as a learner, so we could support you to a maximum extent
- ▶ Technical content of the introduction covered a definition of an embedded systems and metrics