If my calculations are correct, when this baby reaches 88 miles per hour, you're going to see some serious

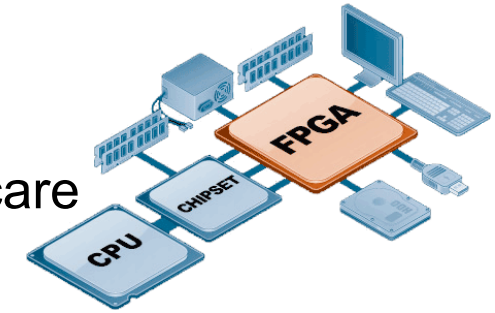
Introduction

ENGN8537

Embedded Systems and Real Time Signal Processing

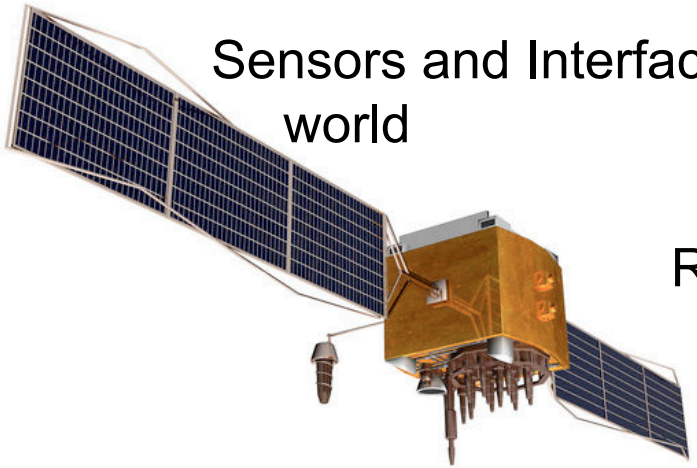
Overview

Review Microcontrollers, FPGAs and why we care



What is “Real Time”? How to recognise it and design for it

Sensors and Interfaces: Your system in the real world



Reliability, Redundancy and making sure your system doesn’t fall over (or lead to others doing the same)

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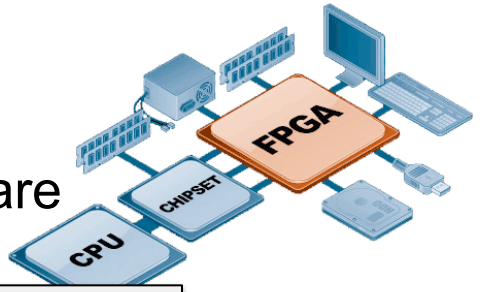
Image credits: 2008 RuggedPCReview.com

Overview



Review Microcontrollers, FPGAs and why we care

Arm you with the tools to go and design real, useful, correct and intelligent Embedded Systems!

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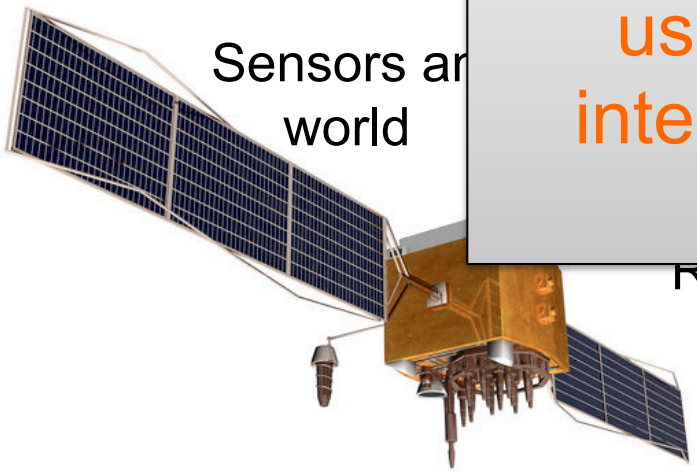
Sensors ar
world



Reliability, Redundancy and making sure your system doesn't fall over (or lead to others doing the same)

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Image credits: 2008 RuggedPCReview.com

Who would be interested?

- Anyone who…
  - Is interested in electronic design and Engineering
  - Wants to be able to design real world electronic systems
  - Would like insight in to nearly every piece of technology around us

Who's giving the course?

Ben Nizette : Lecturer & Tutor

<B332, RSISE Building 115>

Benjamin.Nizette@anu.edu.au

Brad Yu : Convenor & Lecturer

<B353, same building>

Brad.yu@anu.edu.au

Social Media

- University policy is not to “friend” students
- Nothing personal!

Social Media

Course Organisation

- Two hours of lectures a week
  - Theory, concepts and neat examples
- Eight (plus two) labs
  - Where you'll learn the most! You'll see that the world isn't as neat as the lecture examples
- Lectorials
  - A chance to apply what you're learning and gauge your progress
- Major Project
  - The point of the course is to be able to construct an Embedded System you'll get to do just that!
- Final Exam
  - Exam focusing not on numbers and memory, but on problem solving skills and insights

Resources

- No formal text book
- Each topic will be accompanied by a set of recommended readings and reference material
- Lots of reading data sheets, application notes and extraction of technical info from everywhere!

Acknowledgements

Some content inspired by, and built with reference to, Uwe Zimmer's **COMP4330 Real Time and Embedded Systems**

Earlier slides (week 2-3) are prepared with reference to, Gerard Borg's **ENGN3213 Microprocessor and Digital Systems**

Lab material developed with help from the Altera University Program.

Feedback

- This is the second time the course is being run and the first in this format. We value your feedback!
- If you have any comments on the material, pace, style or anything else, please don't hold off until the end of the course.

What is an Embedded System

- An electronic system within a larger device
- A computational system that supports the primary functions of a device
- A computational system with tight constraints on size, power consumption and functional correctness
- … A tricky thing to define!

What Characteristics Do They Have

- Small?
- Fast?
- Multi-threaded?
- Quick Response?
- Efficient?
- “Low Level”?

What Characteristics Do They Have

- ~~Small?~~ Would you call the 787 control systems small?
- ~~Fast?~~ Should be fast anyway!
- ~~Multi-threaded?~~ Applies to most modern computing systems
- ~~Quick Response?~~ Not quick, but predictable
- ~~Efficient?~~ Should be efficient anyway!
- ~~"Low Level"?~~ Applies, at some level, to most computing systems

What Characteristics Do They Have

- Heavily concurrent and/or distributed
- Close to the end sensors/actuators
- Part of larger systems
- Failure often catastrophic and may lead to loss of life, environmental damage, large-scale damage to the system etc.
- Predictability and correctness are the most important criteria

What Characteristics Do They Have

Predictability and correctness are the most important criteria.

What is “Correct” and “Predictable”?

The right result at the right time, every time.

Real Time

Main Topics

- Microcontrollers and FPGAs
  - Recap what you learned in Digital Systems and Microprocessors with a focus on critical analysis of the merits of each architecture
- Real Time
  - Possibly the most important term in the course. You'll learn what it means, why it's important, how to identify systems that require it and how to design systems to guarantee it
- Physical Interfacing
  - No Embedded System lives in isolation, by definition. You'll learn how to connect your system with the world
- Redundancy and Reliability
  - If your PC goes flaky, you reboot it. If your Boeing goes flaky, the situation is a bit more dire

Table of Contents

Date	Week	Lectures	Ref	Labs
22/7	1	Intro	-	None
29/7	2	Recap: Microcontrollers and FPGAs	DSM Notes	Intro to Altera and the DE2
5/8	3	ES Architecture	NG1, NG3	Graphics and Hardware
12/8	4	Embedded Processors	NG 4	Signals and Simulation
19/8	5	Real Time and Determinism	BW9, BW11	Nios II
26/8	6	RTDet 2, Embedded OS	NG9	DSP Builder
2/9	7	Embedded OS 2	NG9	Guided Project Session 1
		Mid-Semester Break		
23/9	8	Sensors and Physical Interfacing	-	Guided Project Session 2
30/9	9	Communications and Memories	NG5, 6, 7	Guided Project Session 3
7/10	10	Physical Integration and Power	-	Guided Project Session 4
14/10	11	Reliability and Redundancy	BW2	Final Project Demonstrations
21/10	12	Effective ES	NG11, NG12	Optional catch-up
28/10	13	Guest Lecture / Exam Prep		
		Exam Period		

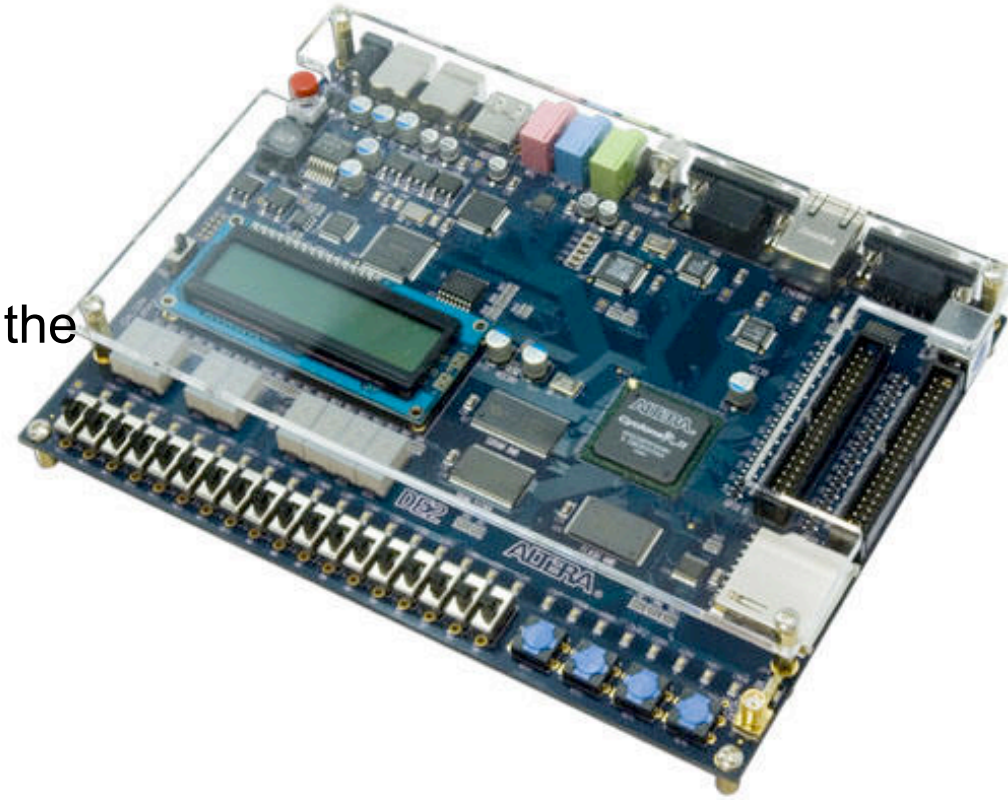
Recommended Reading:

(BW) Burns and Wellings **Real-Time Systems and Programming Languages (Third Edition)**, Addison Wesley Longmain 2001
(NG) Noergaard, T **Embedded Systems Architecture,** Elsevier 2004
White, E. Making Embedded Systems, O'Reilly Media 2012

Software Used

- 10 brand new Altera DE2-115 Development Boards
- Altera Quartus v11.1sp2
- Altera Nios2 Builder
- Nios2 Monitor Program

Nothing particularly different from the Xilinx tools used previously, but a much more capable development board.

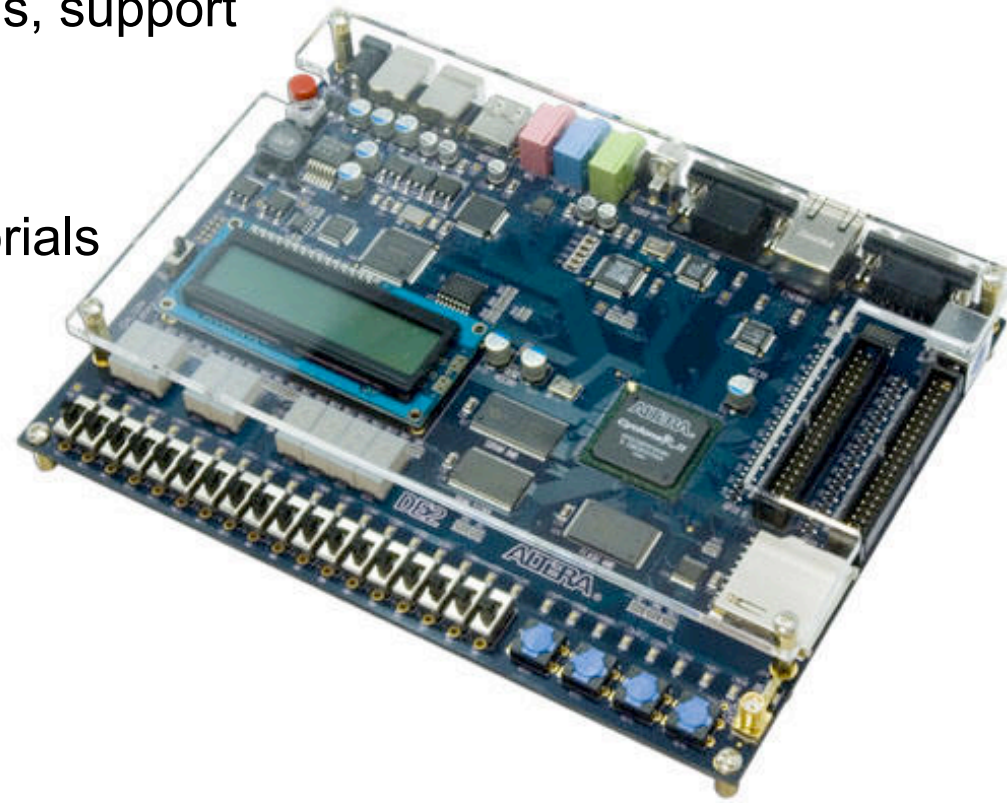


Why Altera DE2-115

The DE2-115 is more capable than the Xilinx boards used in ENGN3213, with better peripherals, support and performance.

Lots of examples, demos and tutorials

Not least of all, Altera gave them to us for free under the generous Altera University Program

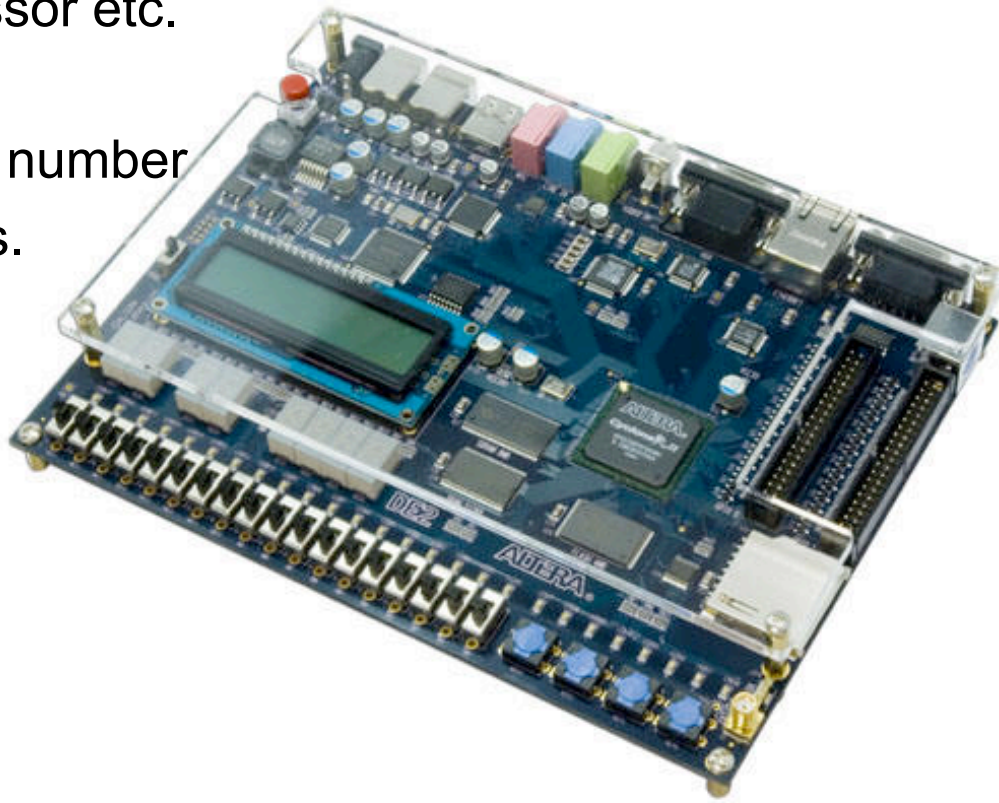


Why Altera DE2-115

Labs will introduce you to all the features of this board, including driving the VGA, audio, LCD, Nios processor etc.

The project will be supported by a number of guided, tutorial-like lab sessions.

The focus is on learning by doing, experimentation and creativity are emphasized over all.



Major Project

- The board will be supplied with full code to drive almost all peripherals, both from hardware and Nios-II procedural code
- It will also be supplied with demo projects that make use of this functionality, including
  - Synthesizing and recording sound
  - Decoding PAL and NTSC video streams
  - Many examples of VGA display usage
  - Ethernet and Web Server functions
  - IR Remote control
- You won't necessarily get better marks if you write your own drivers! If you do, make sure you have a good reason why the supplied ones don't suit your needs
- Marks are based on the quality of design and justification of design decisions above fine implementation details

Major Project

Focus on learning, not (necessarily) implementation.

May use this project to demo your learning outcome in other courses.

Be creative!

We're excited to see what you create, and what you learn in the process.