SE3910 – REAL TIME SYSTEMS

Course Introduction

HOMEWORK FOR LAB

- 1. Watch the video (which includes a quiz)
- 2. Read the lab management plan for S343, the lab we will be in.
  - There will be a quiz on Thursday in Lab.

ABOUT THE INSTRUCTOR

- **Instructor:** Dr. Walter W. Schilling, Jr.
- **Office:** Walter Schroeder Library 335
- **Office Hours:**
  - While I post office hours, I keep an open door policy. If I am in my office and the door is open, please feel free to stop in.
- **Telephone:** 414 277 7370
- **E-mail:** schilling@msoe.edu
  - Best method to contact me during non-class days
  - Please prefix subject with SE3910.
- **Course Web Page:**
  - http://www.walterschilling.us/msoe/spring20132014se3910/spring20132014se3910.php

ABOUT THE INSTRUCTOR (CONTINUED)

- Ohio Northern University graduate in Electrical Engineering
  - Computer Science Minor
- Masters and PhD. from University of Toledo
  - Specialized in Computer Systems Design and Software Reliability
- Worked in Automotive Industry for approximately 6 years
  - Audio Software Engineer – Embedded Systems Design
    - US Patent 6,707,768
    - "Randomized Playback of Tracks i[illegible]

- Personal Website: http://www.walterschilling.org

CATALOG DESCRIPTION

- This intense design course introduces students to software development for real-time systems, which often have stringent timing constraints that must be satisfied even under adverse circumstances. Real-time applications include flight control systems, vehicle control systems, industrial processes, life-support systems, robotic manipulators and multimedia applications. Special attention is paid to scheduling, latency minimization, bandwidth constraints, and other design issues that impact the design of these systems. Laboratory assignments provide experience in the design and implementation of realistic applications using a real-time operating system and embedded development board. This course introduces students to software development for real-time systems, which often have stringent timing constraints that must be satisfied even under adverse circumstances caused by component failures. Real-time applications include flight control systems, vehicle control systems, industrial processes, life-support systems, robotic manipulators and multimedia applications. Special attention is paid to scheduling, latency minimization, bandwidth constraints, and other design issues that impact the design of these systems. Laboratory assignments provide experience in the design and implementation of realistic applications using a real-time operating system and embedded development board. (prereq: CS 2710 or CE 2930, CS 3844 or CS 3841)

CATALOG DESCRIPTION

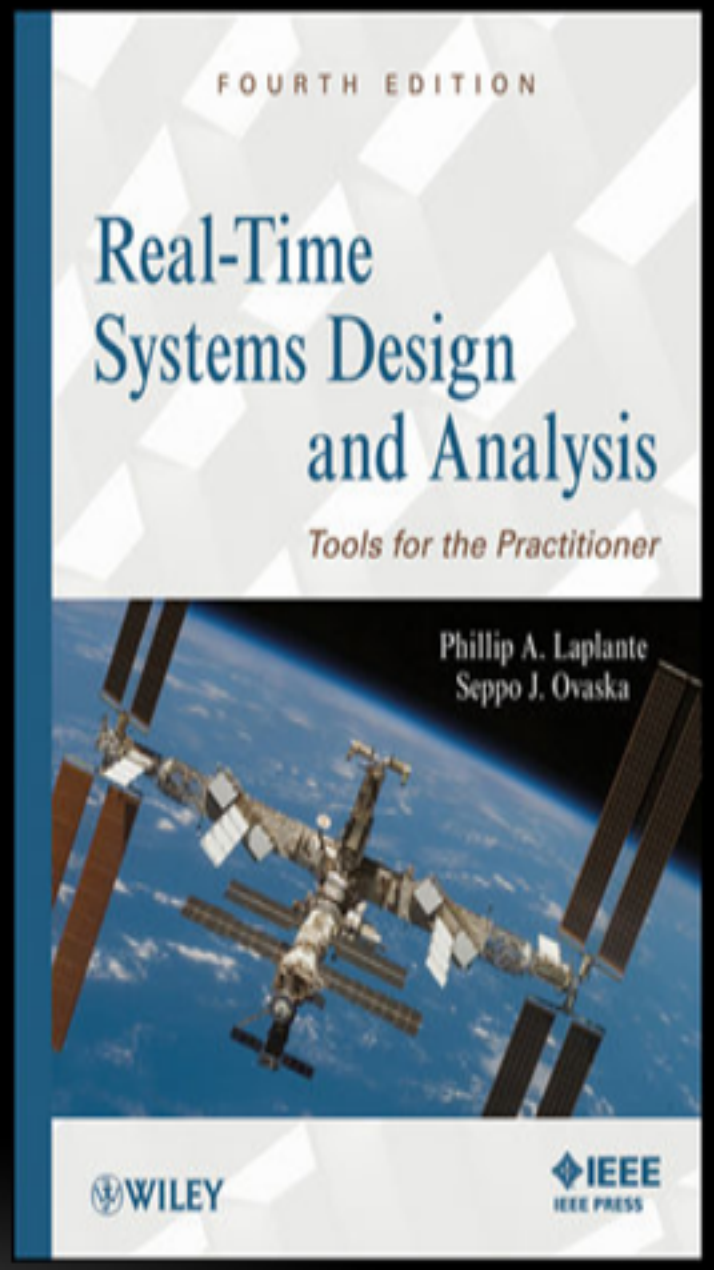
- This intense design course introduces students to software development for real-time systems, which often have stringent timing constraints that must be satisfied even under adverse circumstances. Real-time applications include flight control systems, vehicle control systems, industrial processes, life-support systems, robotic manipulators and multimedia applications. Special attention is paid to scheduling, latency minimization, bandwidth constraints, and other design issues that impact the design of these systems. Laboratory assignments provide experience in the design and implementation of realistic applications using a real-time operating system and embedded development board. This course introduces students to software development for real-time systems, which often have stringent timing constraints that must be satisfied even under adverse circumstances caused by component failures. Real-time applications include flight control systems, vehicle control systems, industrial processes, life-support systems, robotic manipulators and multimedia applications. Special attention is paid to scheduling, latency minimization, bandwidth constraints, and other design issues that impact the design of these systems. Laboratory assignments provide experience in the design and implementation of realistic applications using a real-time operating system and embedded development board. (prereq: CS 2710 or CE 2930, CS 3844 or CS 3841)

PREREQUISITES

- CS2710 Computer Organization or CE2930 Computer Architecture
- CS3844/CS3841 Operating Systems

TEXTBOOK

- Real-Time Systems Design and Analysis: Tools for the Practitioner, 4th Edition
- Phillip A. Laplante, Seppo J. Ovaska
- ISBN: 978-0-470-76864-8
- 584 pages
- November 2011, Wiley-IEEE Press



CLASS MATERIALS

- Textbook(s)
- Calculator
- Beaglebone Black Kit
  - Purchase from Tech Support with keypad/display kit
  - Also used in other junior/senior courses
- 2 8 GB Micro-SD Cards
- Laptop Computer with MSOE Image
  - Virtual Box Virtual Machine Software
  - ethernet cable (2x for lab)

GRADING

Midterm Exams (1)	30%
Lab Work	25%
Homework / Quizzes	15%
Final Exam	30%
Total	100%

GENERAL NOTES

- **Assignment Due Dates**
  - Late Penalty
    - 10% per business day late penalty for all written work
    - No work will be accepted more than 5 business days late for credit.
  - Early Bonus
    - Early submission bonus will be available for all lab assignments.
    - 10% bonus for lab assignments submitted 48 hours or more in advance of the due date
    - 5% for lab assignments submitted 24 hours or more in advance of due date.

GRADING CHALLENGES

- Any grading challenges, unless specifically noted by the professor, shall be submitted in writing within 5 days of the assignment being returned to the student.
- Challenge must clearly delineate the problem with the assignment grade as well as justify the need for the grade change.

STUDENT INTEGRITY

- All students are expected to abide by MSOE's policy on student integrity. If at any point in the semester you have a question about an assignment, please come discuss it with me.
- Violations of this policy will be dealt with seriously, and may result in significant penalty, up to and including failure of the course.

LECTURE NOTES / HANDOUTS

- Lecture notes will be available online in the ubiquitous presenter system
  - http://up.ucsd.edu/
  - You will need to subscribe to the course
  - You may also follow along with the lecture online

SE3910 MSOE → All Caps

- Non slide lecture material and handouts may be made available on the website.
  - These are for your own personal usage and are not to be circulated outside of the MSOE domain.
- Lecture notes and handouts are subject to copyright law.

PIAZZA DISCUSSION BOARD

- There is a discussion board for this class on the service Piazza
  - Usage of this board is purely optional
  - Questions may be answered faster there than via e-mail

COURSE COVERAGE

- See Syllabus

LECTURE OBJECTIVES

- Explain what an embedded system is.
- Explain what a Real-Time System is.
- Compare and contrast microcontrollers and microprocessors
- Quantify the importance of embedded systems in the computing domain
- Explain the difference between Embedded and PC applications

WHAT IS REAL-TIME SYSTEM

System which can respond quickly....

A system which can constantly monitoring its enviroment....

WHAT IS A REAL-TIME SYSTEM

- correctness of the system depends not only on the logical results, but also on the **time** in which the results are produced.
- works in a reactive and time-constrained environment

- Random House Dictionary:
- "pertaining to applications in which the computer must respond as rapidly as required by the user or necessitated by the process being controlled."

REAL-TIME SYSTEM EXAMPLES

- Temperature control of a chemical reactor
- Space mission control system
- Nuclear power generator system
- Many safety-critical systems

WHAT IS AN EMBEDDED SYSTEM

SE3910 REAL TIME SYSTEMS

WHAT IS AN EMBEDDED SYSTEM

- a combination of hardware & software (a "computational engine") to perform a **specific** function
- is part of a larger system, say a real-time system, that may not be a "computer"
- works in a reactive and time-constrained environment

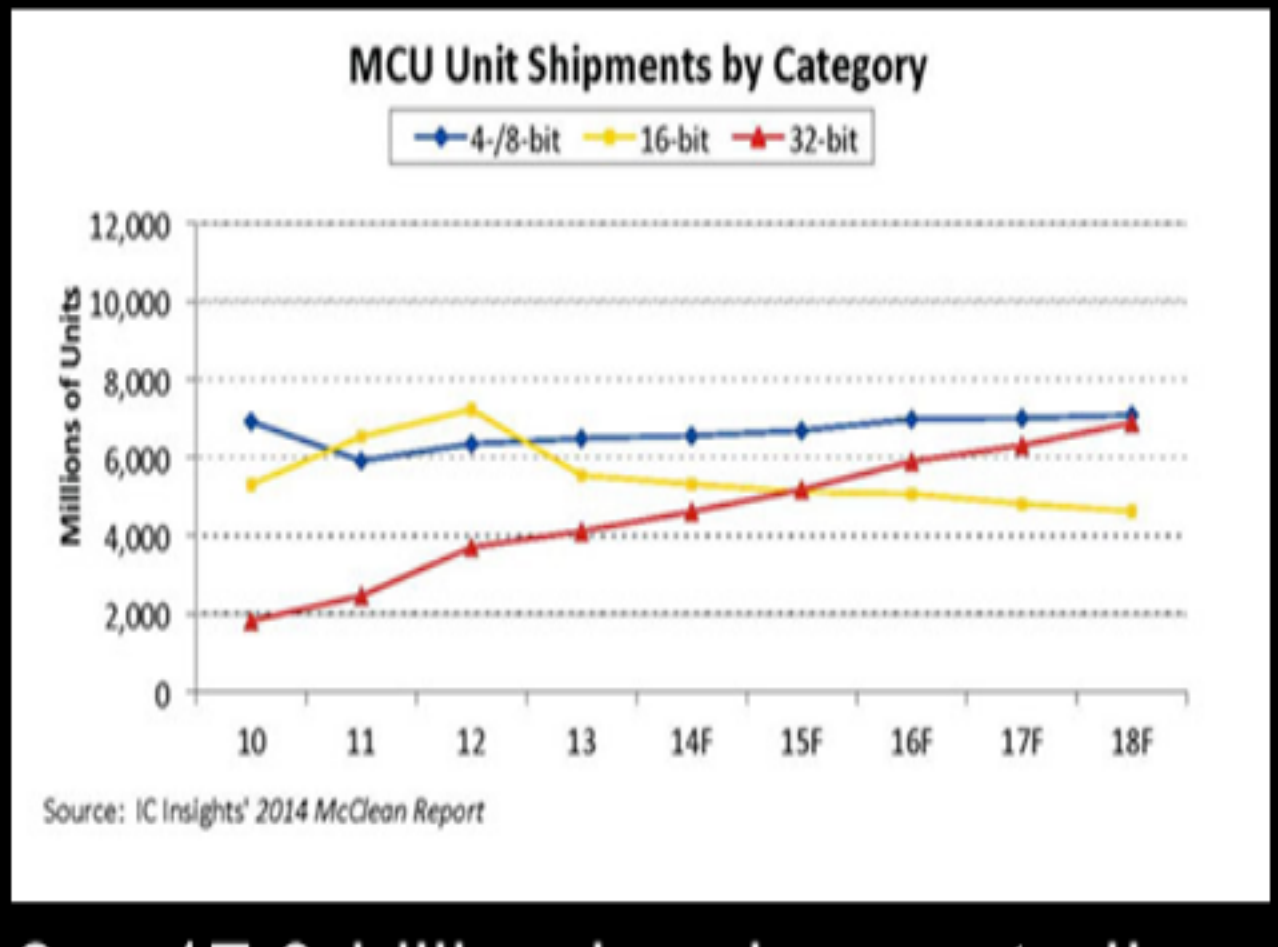
EXAMPLES OF EMBEDDED SYSTEMS

- Appliances: microwaves, VCRs, dishwashers, refrigerators, furnaces, clocks
- Medical devices: hearing aids, pacemakers, …
- Car systems: antilock brakes, engine timing and monitoring, seat/mirror positioner, air handling, lighting/environment
- Mobile phones, PDA's, Music players, remote controls

EMBEDDED RULES!

- Embedded processors account for 100% of worldwide microprocessor production!
- Embedded:desktop = 100:1
- 1999: #embedded processors in the home
  - estimated at 40-50 and growing

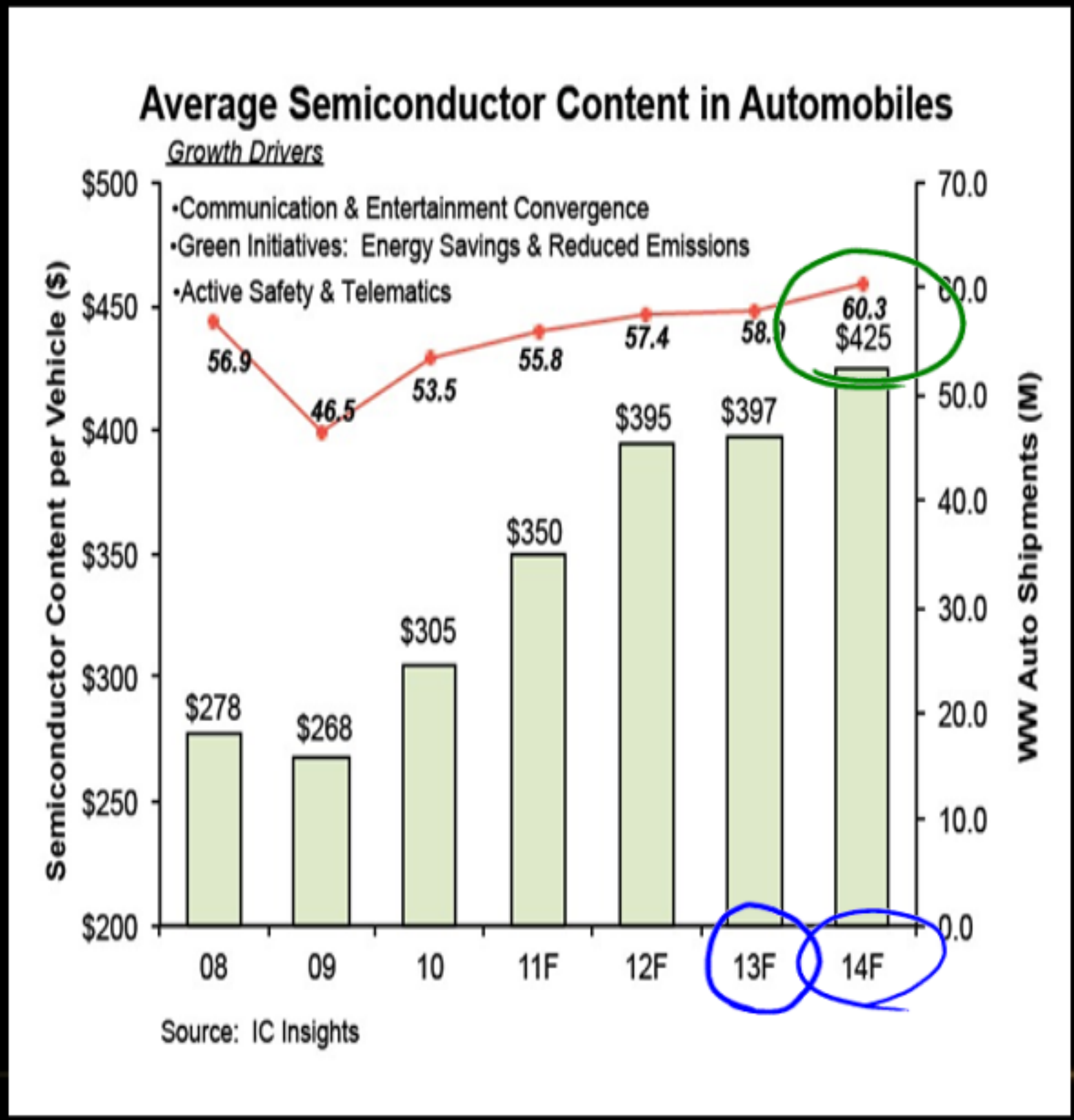
ARE EMBEDDED SYSTEMS A SMALL PIECE OF THE COMPUTING PIE?



Source: IC Insights' *2014 McClean Report*

- 2012-> 17.3 billion in microcontroller sales
- 2013 Estimates (EE Times)
  - 16 bit -> 7.9 billion (9% growth)
  - 8 bit -> 6.7 billion (7% growth)
  - 32 bit -> 4.5 billion (20% growth)

MICROCONTROLLERS IN AN AUTOMOBILE



SE3910 REAL TIME SYSTEMS

EMBEDDED SYSTEMS VERSUS PC SYSTEMS

Dedicated to one specific task	Can do many different tasks
Has a single program, as a result, can be made inexpensively to include just enough computing power and hardware to perform that dedicated task	Runs many different types of programs and can be re-configured to do each task optimally
Program is usually permanently "burned" into memory when manufactured	Program is loaded into memory when needed –usually from hard drive.
Has a low-cost microcontroller unit (MCU) for its intelligence, with many peripheral circuits on the same chip, and with relatively few external devices	Has a relatively expensive generalized central processing unit (CPU) at its heart with many other external devices (memory, disk drives, video controllers, network interface circuits, etc.)
Often, an embedded system is an invisible part, or sub-module of another product, such as a cordless drill, refrigerator or garage door opener. The controller in these products does a tiny portion of the function of the whole device. The controller adds low-cost intelligence to some of the critical sub-systems in these devices	Usually, a large system, often part of a network, employed for word processing, spreadsheet calculations, presentations, internet interface, GUI for various PC-based tools.

Embedded

PC