Final Design Project: Homing Bot

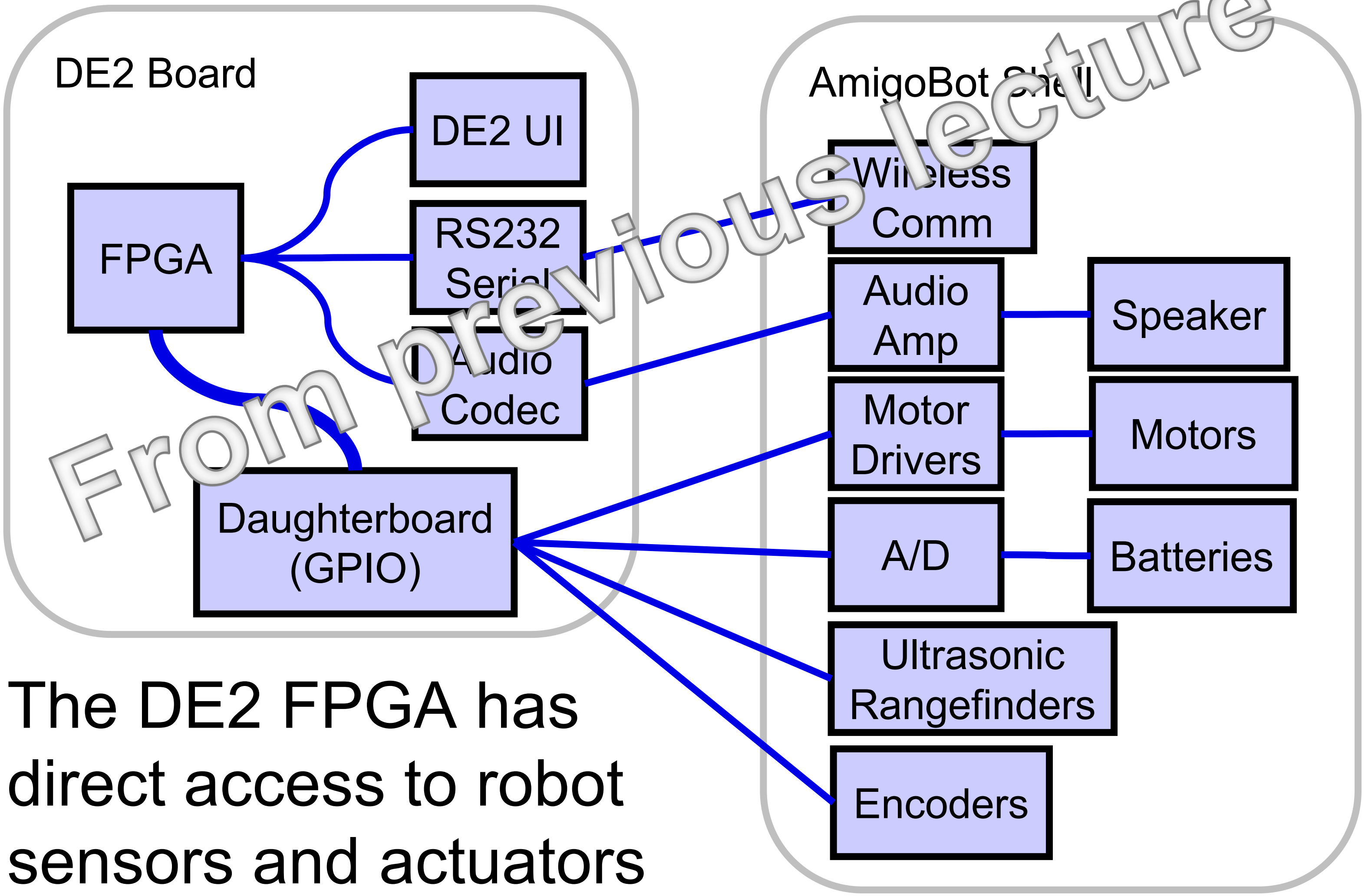
Localization with sonar scans

ECE2031 Fall 2018

Introduction

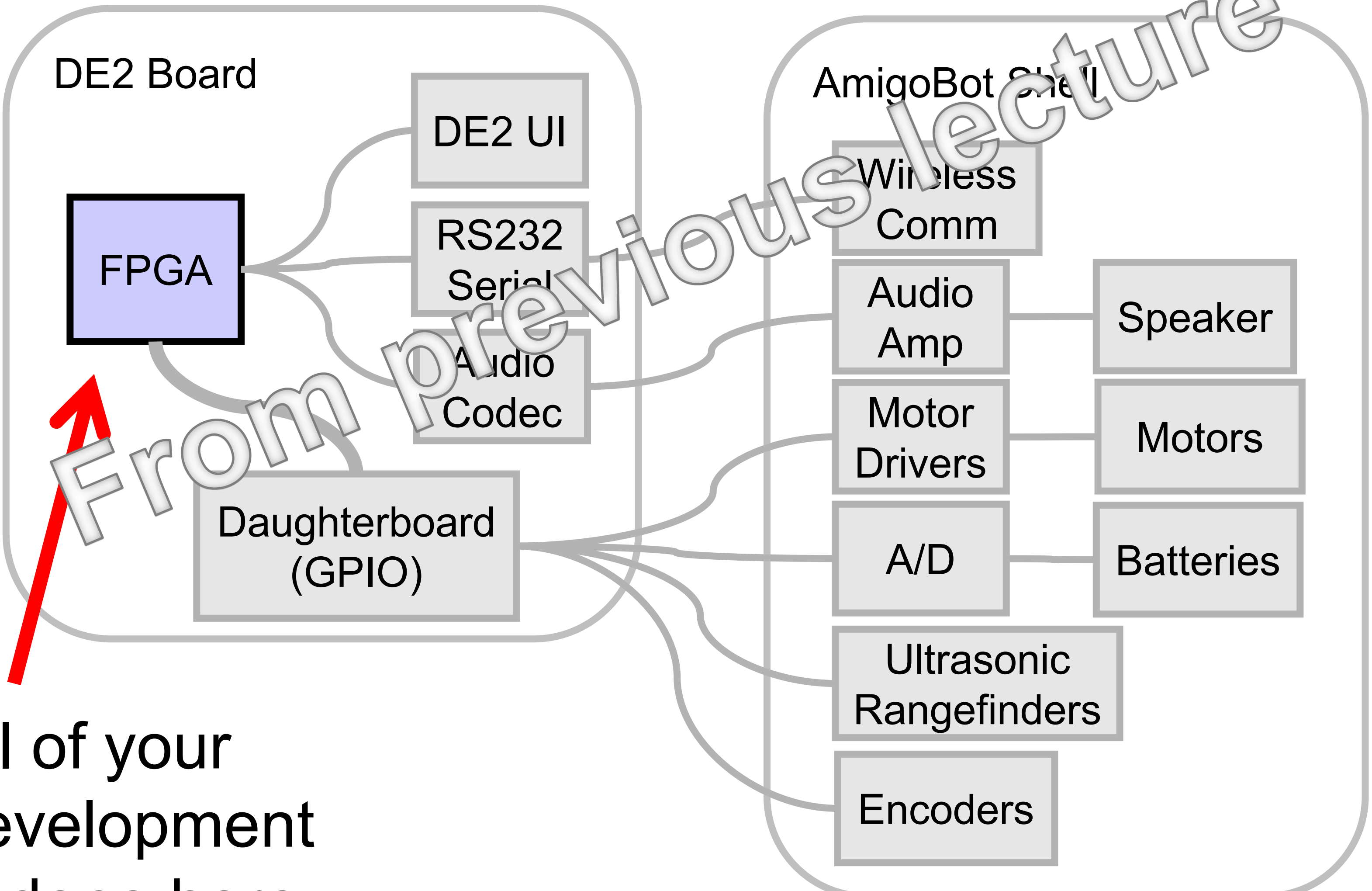
- Don’t forget – we had an introductory lecture three weeks ago
- This picks up where that left off

DE2Bot Hardware Architecture



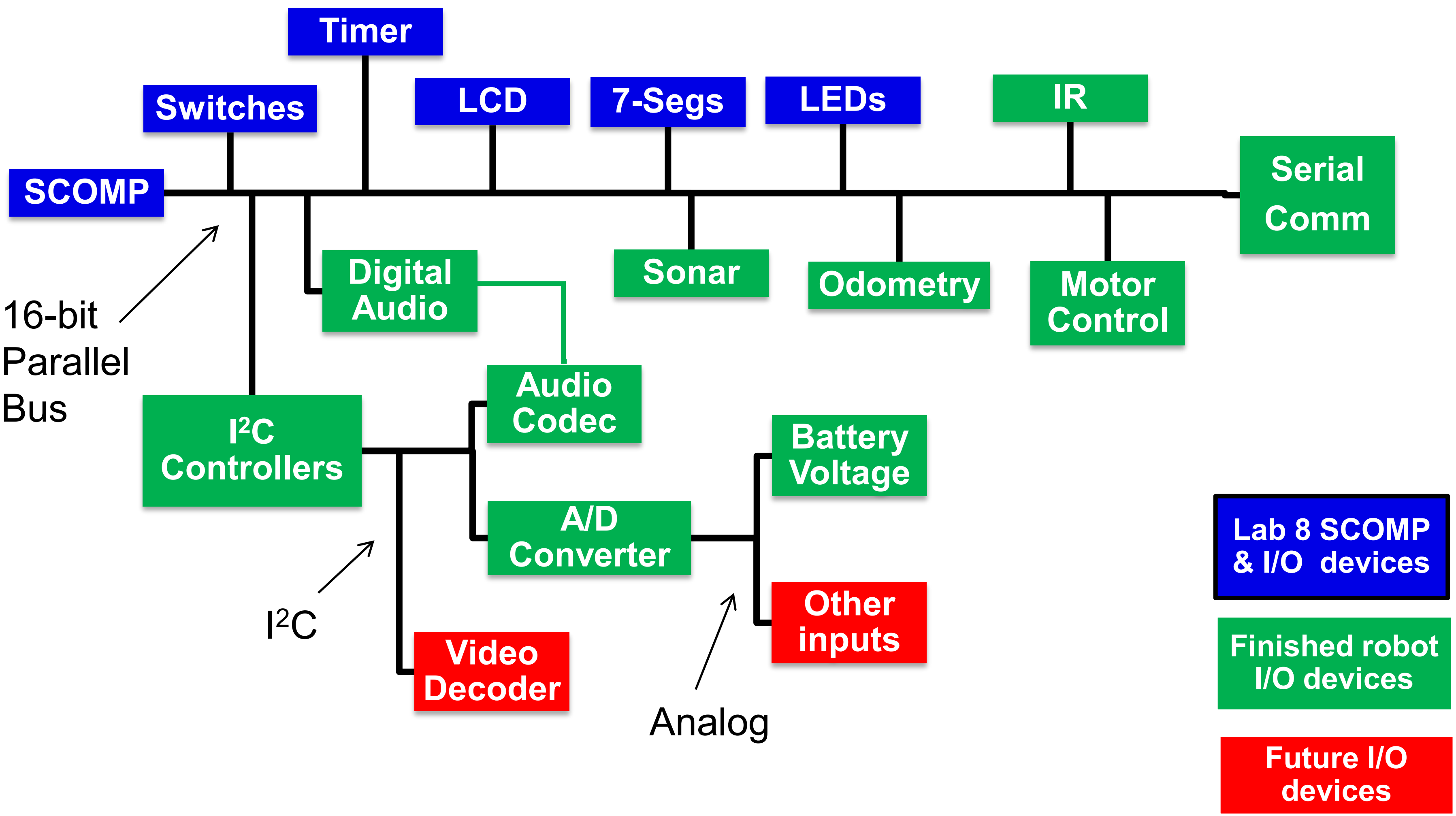
- The DE2 FPGA has direct access to robot sensors and actuators

Project Development



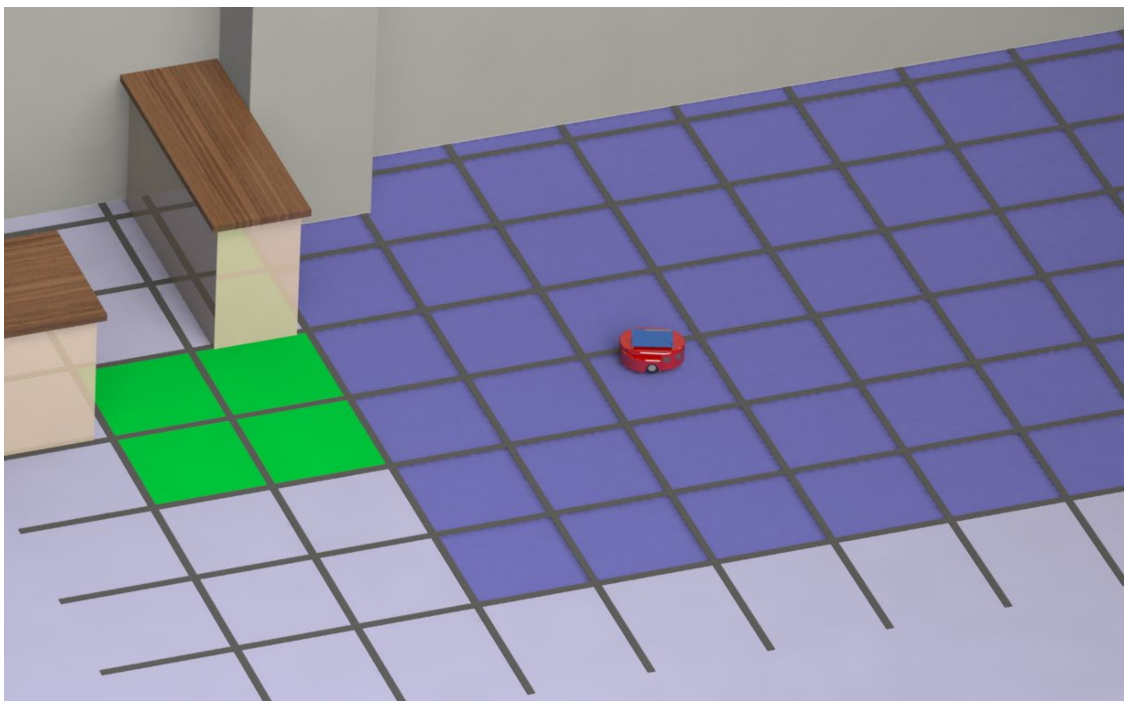
All of your development is done here

DE2 and FPGA System Architecture



Your Design Task for Fall 2018

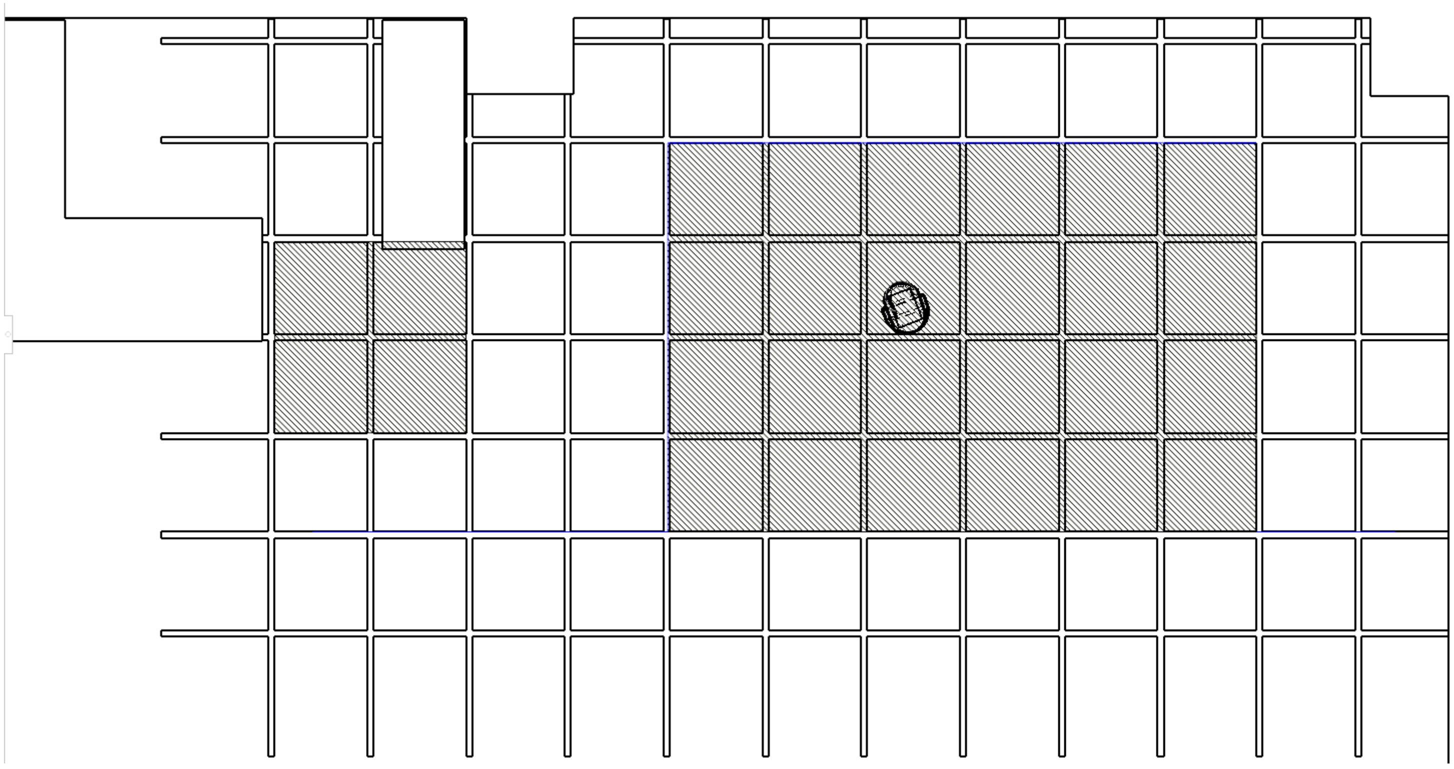
- For a robot randomly placed in an area…
  - Make it go to its “home”



- Grid represents carpet tiles
- Home is the green area
- Blue area will be clear – no people, chairs, etc.
- Starting point will be somewhere in clear area
  - Details to follow

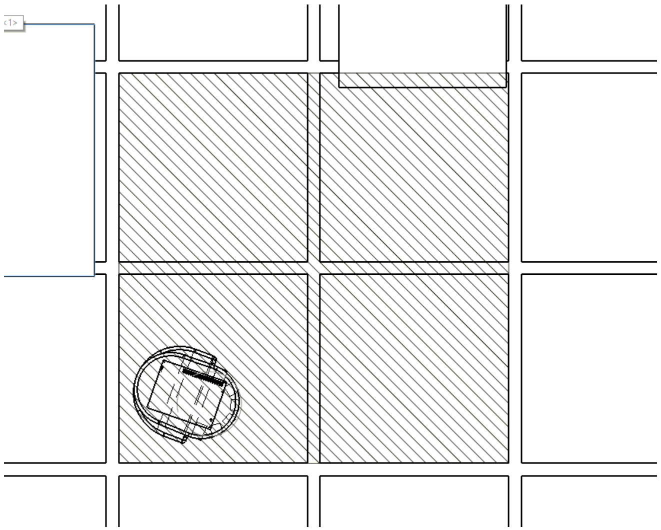
Demo “runs”

- Each of “run” consists of starting from the shaded region on the right and trying to get home.
- The entire body of the robot will be within the starting region boundaries at the start of each run (different locations each time)

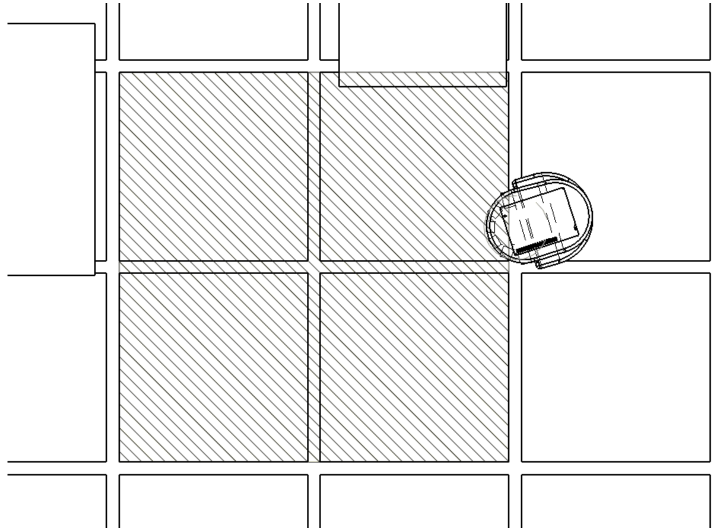


Scoring for arriving at home

- Most of the points are given based on being in or out of home at the end of the run (when robot stops or time runs out)
  - The entire body of the robot inside the carpet squares awards 600 points
  - Half as many points (300) for being partly in the home region
  - No points for finishing anywhere else
  - No prorating based on percentage of the robot inside the home region



600 points



300 points

Other scoring factors

- Each team performs three 2-minute runs, using a different robot each run
  - Every team does one run, <u>then</u> all do second run, <u>then</u> all do third run
- Score for each run
  - Inside/On-the-line/Outside (previous slide): 600/300/0 points
  - Progress points: 100 points prorated from starting location to center of home area (0 points for no progress, 100 points for perfect finish)
  - Seconds remaining: one point per second remaining
  - Any non-zero number of collisions: -50 points
- Demo score is sum of two best runs
  - Lowest of the three runs is discarded
- Demo <u>scores</u> across all sections are curved to produce a <u>grade</u> (normally between 70-100%)

Hard-mode Option

- For each run, a team may opt-in for a more difficult starting location:
  - Within the “clear area”, outside the normal starting area, not closer than 6 in. to any wall or object
- Taking this option increases the “progress” points from 100 to 200
  - Still no points if you make no (or negative) progress
  - Still no goal points if you don’t make it to the goal
- Do not start the project with this option in mind. Only attempt it after you are confident within the normal starting area.

Materials provided

- Working SCOMP and robot peripherals
- Movement API and other code used in initial exercises
- Arctangent, Pythagorean distance, Multiplication, Division, Modulus
- Code that spins robot in place, storing 360 sonar readings in an array
- Code that shows how to index through an array of 360 values

Design Space (factors that drive design choices)

Reliance on odometry:

- How long can you rely on odometry?
- Should you avoid it altogether?

Integration of sonar and odometry:

- Once robot “knows” where it is, does it ignore sonar?
- If initial scan is confusing, does odometry provide useful information to take robot to a spot where sonar should expect better readings?

General:

- Speed and type of robot movement (e.g., continuous vs. stop-and-turn)
- Use of one sonar vs. multiple sonars
- ?? (That’s why you brainstorm)

What is reasonable?

- This is deliberately open-ended
- There is no “perfect result,” and no “this score will earn this grade”
- Your peers are in the same situation
- Do not overreach (and over-propose)
  - Proposing a “perfect solution” is doomed
- Propose a progressive path with incremental performance improvements

Time management

- Focus on how you can build towards a certain result by completing smaller tasks.
- If you spend “normal” 2031 time and use that time wisely, you'll end up with an acceptable project
  - Typically, most 2031 projects are split A/B, with only a very few C grades
  - A conscientious effort is what we expect, and no more time in lab than you would normally spend (splitting effort among the team)

Project tasks vs. tasks in Labs 1-8

- Replace time spent on prelab work with preparation
  - Adjust your overall plan according to what you've finished and how much time you have left
  - Plan how you will use robot time in lab
- Use lab time to make incremental progress
- The time previously spent assembling lab results can be used to assess current progress

Lab activity

- Do not all work on one piece of code
  - One or two team members can code
  - One or two can run tests
  - Some can work on deliverables like the proposal
- Open hours are still available
  - Offered for convenience, not because we require you to use them
  - Maintain a balance between this class, other classes, and personal time

Robot Logistical Details

- ONE robot per team
- Check out robots with a BuzzCard
  - You will get a long USB cable as well
- During your lab section, you will always have a robot available to you
- During open hours, robots are first-come first-served
  - With time limits imposed if robots are in high demand

Information on DE2Bot

- The downloadable **DE2Bot Manual** includes many details about the robot and how to use it.
- If you want to know something more, ask on Piazza

Name	IO Address	IN/OUT	Description
SWITCHES	0x00	IN	Read DE2 switch
LEDS	0x01	OUT	Write to DE2 LE
TIMER	0x02	IN/OUT	Read 10Hz timer
XIO*	0x03	IN	Read PB3-PB1,
SSEG1	0x04	OUT	Write to left 4-di
SSEG2	0x05	OUT	Write to right 4
LCD	0x06	OUT	Write to LCD (16
XLEDS	0x07	OUT	Write to DE2 LED
BEEP	0x0A	OUT	Write 1-7 for be
CTIMER	0x0C	OUT	Configurable tir
LPOS*	0x80	IN	Read the current
LVEL*	0x82	IN	Read the curren
LVELCMD*	0x83	OUT	Write the desir
RPOS*	0x88	IN	Read the current
RVEL*	0x8A	IN	Read the curren
RVELCMD*	0x8B	OUT	Write the desire
I2C_CMD*	0x90	OUT	Write configurati
I2C_DATA*	0x91	IN/OUT	Read or write d

Project Starting Point

- You will have a complete SCOMP
  - Implements all instructions in Table 7.1 of lab manual
  - Implements additional instructions detailed in robot manual
  - Implements a 10-level subroutine call stack
  - Has twice as much program memory (2048 words)
  - Supports hardware interrupts from four sources
- You will have a complete DE2Bot Quartus project
  - Has working interfaces with all DE2 I/O (switches, LEDs, etc.)
  - Has an additional DE2 I/O device working (LCD)
  - Has the full complement of robot I/O devices
- You will have some example ASM code and useful subroutines (described earlier)

Next Week in Lab

- There will be one last pre-lab quiz
  - Covering these slides, and any other project material on Canvas
- You will have some specific things to do
  - Form groups and share your brainstorming ideas
  - Learn to use the robot self-test
  - Implement some basic robot movement
- If you complete the exercises before your lab period is over, don't waste that extra time
  - You have four lab sessions (including next week) and some open hours to complete this project
  - The lab will be busy in the last few days
    - Robots will be rationed – not guaranteed outside of your section
    - Don't count on completing significant work during that time

Project Phases and Key Dates

- Introductory exercises (next week in lab)
  - Form project groups
  - Complete guided tasks (previous slide)
- Proposal presentations November 12^{th} – 16^{th}
  - Incorporate brainstorming ideas into a polished presentation
- Work on project in your lab section and as needed in open hours
  - After next week's guided tasks, you decide how to spend your time
  - Keep a design logbook, which will be used for the design summary
- Complete your design by November 20^{th}
  - You <u>will not be able to work in the lab after this day</u>
- Final demonstrations in lab November 26^{th} -29^{th}
  - Demonstrate your solution in your section
- Turn in final design summaries by the following Tuesday, December 4^{th} at 3:00 PM (on Canvas)

Project Schedule

	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
	28-Oct	**29-Oct**	**30-Oct**	**31-Oct**	**1-Nov**	**2-Nov**	**3-Nov**
Lab Activity	OPEN HRS	Project Initial Exercises				OPEN HRS	CLOSED
Lecture Topic					Written Exam		
	4-Nov	**5-Nov**	**6-Nov**	**7-Nov**	**8-Nov**	**9-Nov**	**10-Nov**
Lab Activity	OPEN HRS	Project Work				OPEN HRS	CLOSED
Lecture Topic					TBD		
	11-Nov	**12-Nov**	**13-Nov**	**14-Nov**	**15-Nov**	**16-Nov**	**17-Nov**
Lab Activity	OPEN HRS	Project Work				OPEN HRS	CLOSED
Lecture Topic					Design Summary		
	18-Nov	**19-Nov**	**20-Nov**	**21-Nov**	**22-Nov**	**23-Nov**	**24-Nov**
Lab Activity	OPEN HRS	Finish Project		HOLIDAY			CLOSED
Lecture Topic					No Lecture (holiday)		
	25-Nov	**26-Nov**	**27-Nov**	**28-Nov**	**29-Nov**	**30-Nov**	**1-Dec**
Lab Activity	CLOSED	Project Demos				OPEN HRS	CLOSED
Lecture Topic					No Lecture		

Clarifications

- Additional announcements and clarifications will be posted **on Piazza**
  - You are responsible for information posted there
  - Could include changes to rules or assignments
  - Make sure you are monitoring it!
- Use Piazza to ask questions
  - If a general question is asked, everyone can benefit from the answer
  - If your question contains details specific to your design, you can limit the visibility to only instructors
  - Especially if you think your idea might be against the "spirit" of the project, ask us about it.