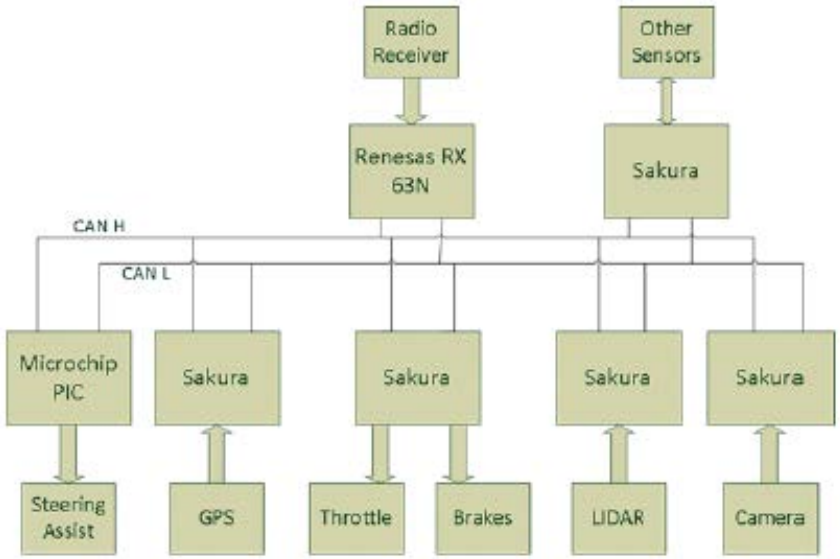
Embedded Systems Development

James M. Conrad, University of North Carolina at Charlotte, USA

Outline of talk

Part 1:

- What an embedded system is
- Why to embed a computer
- What functions and attributes embedded systems need to provide



Part 2:

- Trends in Embedded System Development

Part 3:

- Examples of Research in Embedded Systems and Robotics at UNC Charlotte

First of All, Who Am I?

James M. Conrad, Professor
Dept. of Electrical and
Computer Engineering
University of North Carolina
at Charlotte, USA

Worked at:

- IBM
- Ericsson and Sony Ericsson
- Two start-ups
- Three universities
- Consultant (iRobot, Emerson, others)

All experiences were in the field of embedded systems.

Part 1: What is an Embedded System?

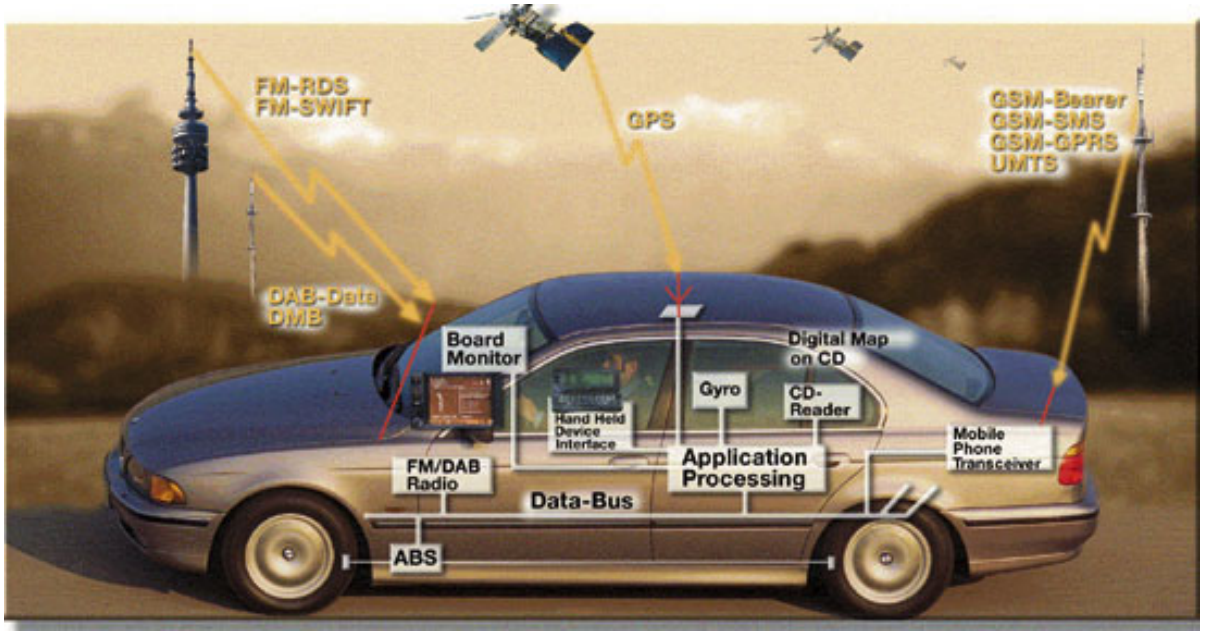
- Application-specific computer system which is built into a larger system or device
- Often runs dedicated software
- Often there to replace previously electromechanical components

[1]

What are the Benefits of Embedded Systems?

- Reduced cost
- Increased functionality
- Improved performance
- Increased overall dependability

The following slides will explore these aspects of embedded systems by using an automobile as an example



[2]

Using an Automobile as an Example

Lower costs

- Components costs: Embedded software can compensate for poor signal quality
- Manufacturing costs: Control Area Network in a car reduces assembly and parts costs due to the simpler wiring harness
- Operating costs: Embedded systems allow automobile engines to operate more efficiently by constant monitoring
- Maintenance costs: Notifying the user when an oil change is due will extend the engine life

Using an Automobile as an Example

[3]

More features

- Cruise control
- Smart airbags
- Power seats
- Headlights and Interior Lights Automation

Better Dependability

- Engine controllers can provide limp-home modes to keep the car running even if one or many sensors fail
- Warning of impending failure can be provided, eg: check engine light
- Diagnostic information can be provided to the driver or service personnel

Attributes of Embedded Systems

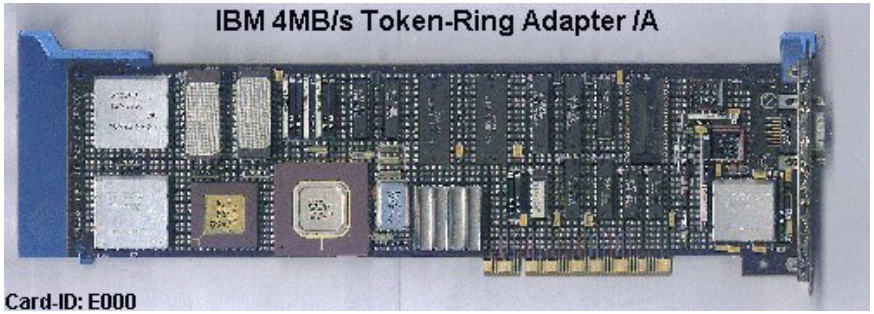
- Embedded systems respond to events which occurs in the environment. For example: a user pushing a button, or a motor overheating
- For real-time systems, certain applications require a response from the embedded system within a certain time frame. For example: igniting the fuel in a cylinder since bad timing may damage the engine
- Embedded systems require fault handling in order to ensure safe and reliable operation
- Embedded systems may be expected to operate independently for years without the need for adjustment or resetting. Developing perfect software is difficult and can be expensive.

Who Works Developing Embedded Systems?

- Mechanical Engineers design the device enclosure
- Electrical Engineers design the circuit boards and components on the circuit boards
- Software Engineers design and write code which interfaces with the user and performs the specific device application
- Computer Engineers design and write software to control the hardware
- Manufacturing and Industrial Engineers design the assembly lines which make the devices
- Systems Engineers make sure the mechanical, electrical, and computer components of a device work together

History of My Projects

IBM Token Ring Network Adapter Card (1984)



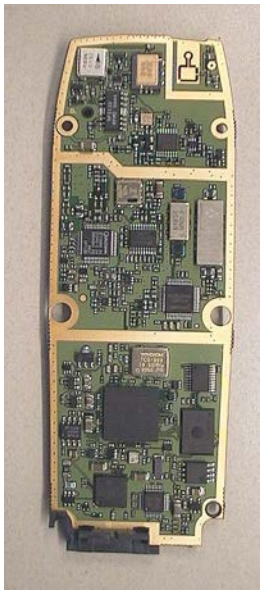
BPM Personal Modeler 3D-Printer (1996)

IBM InfoWindow Touch Screen Display (1986)

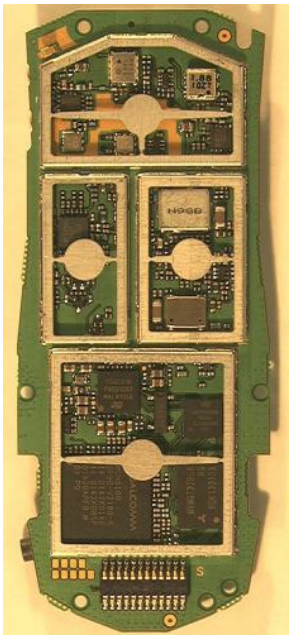
Ericsson Personal Wireless Telephone (PWT) In-building System (1998)

History of My Projects (Cont.)

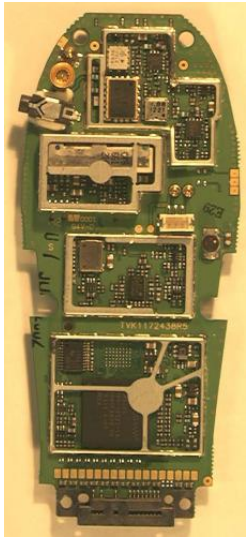
Ericsson's 1st CDMA phone (2000)



Sony Ericsson T206 (2003)



Sony Ericsson T61c (T60c) (2002)

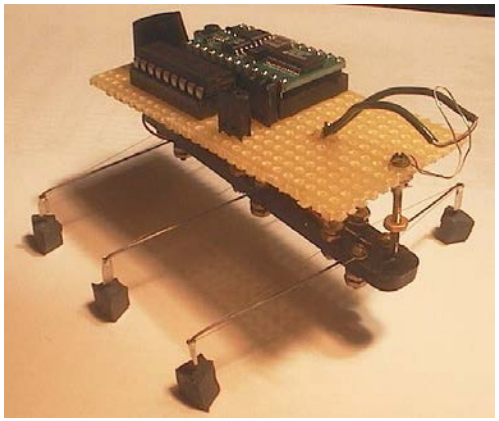


Phone outside photos © Ericsson and Sony Ericsson

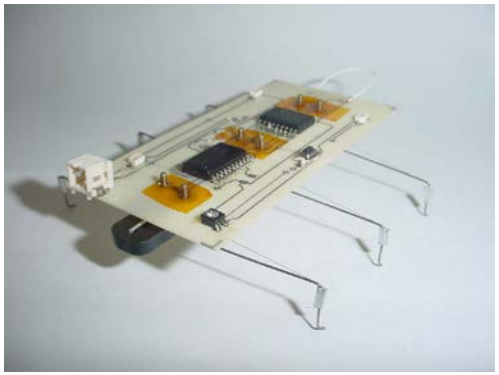
History of My Projects (Cont.)

Stiquito Controlled Robot

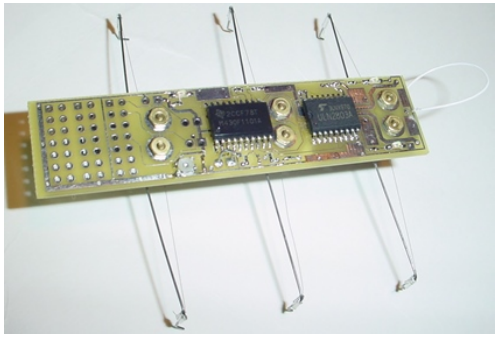
V0.1 (1998)



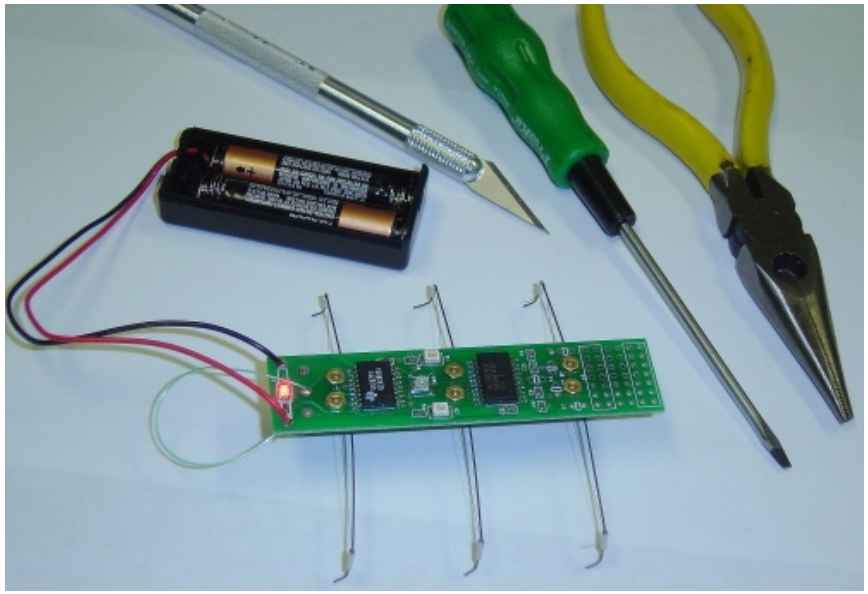
V0.2 (2002)



V0.3 (2004)



V1.0 (2005)



Part 2: Industry Trends with Comments

A survey was taken among developers of Embedded Systems. Major finders are recounted here:

General

General applications

Process

Operating Systems

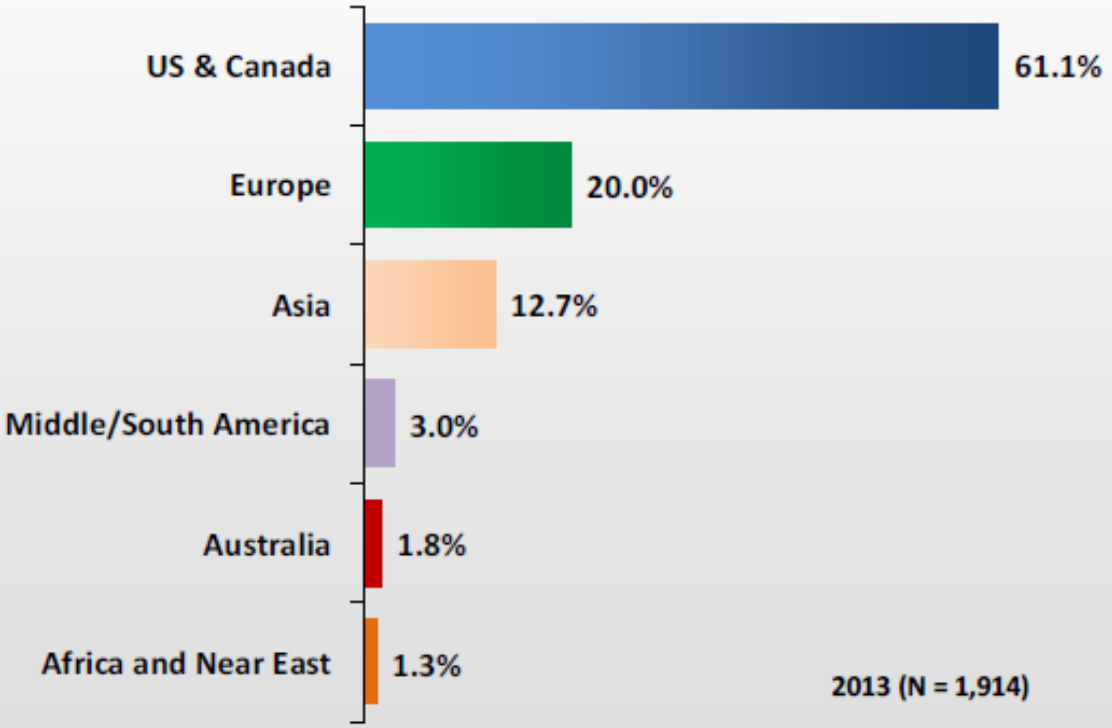
Microprocessors

FPGAs

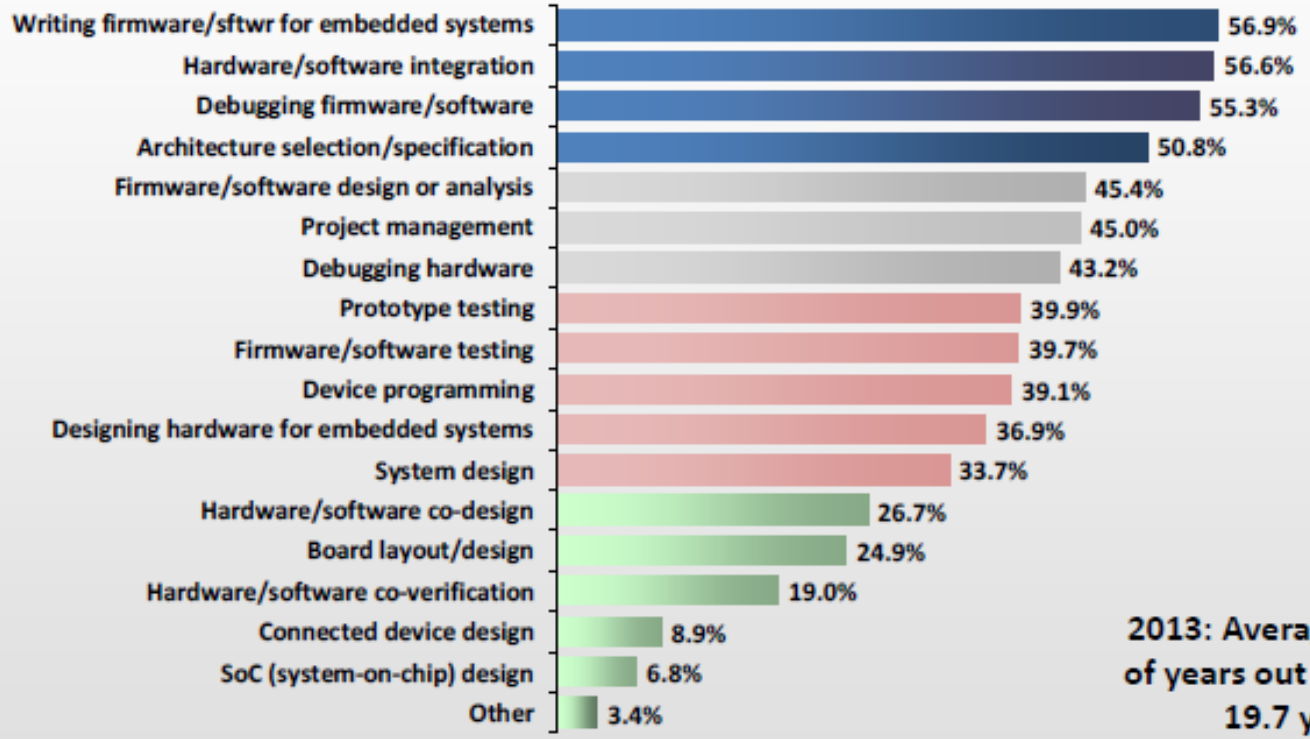
Tools

Used by permission

In which region of the world do you reside?



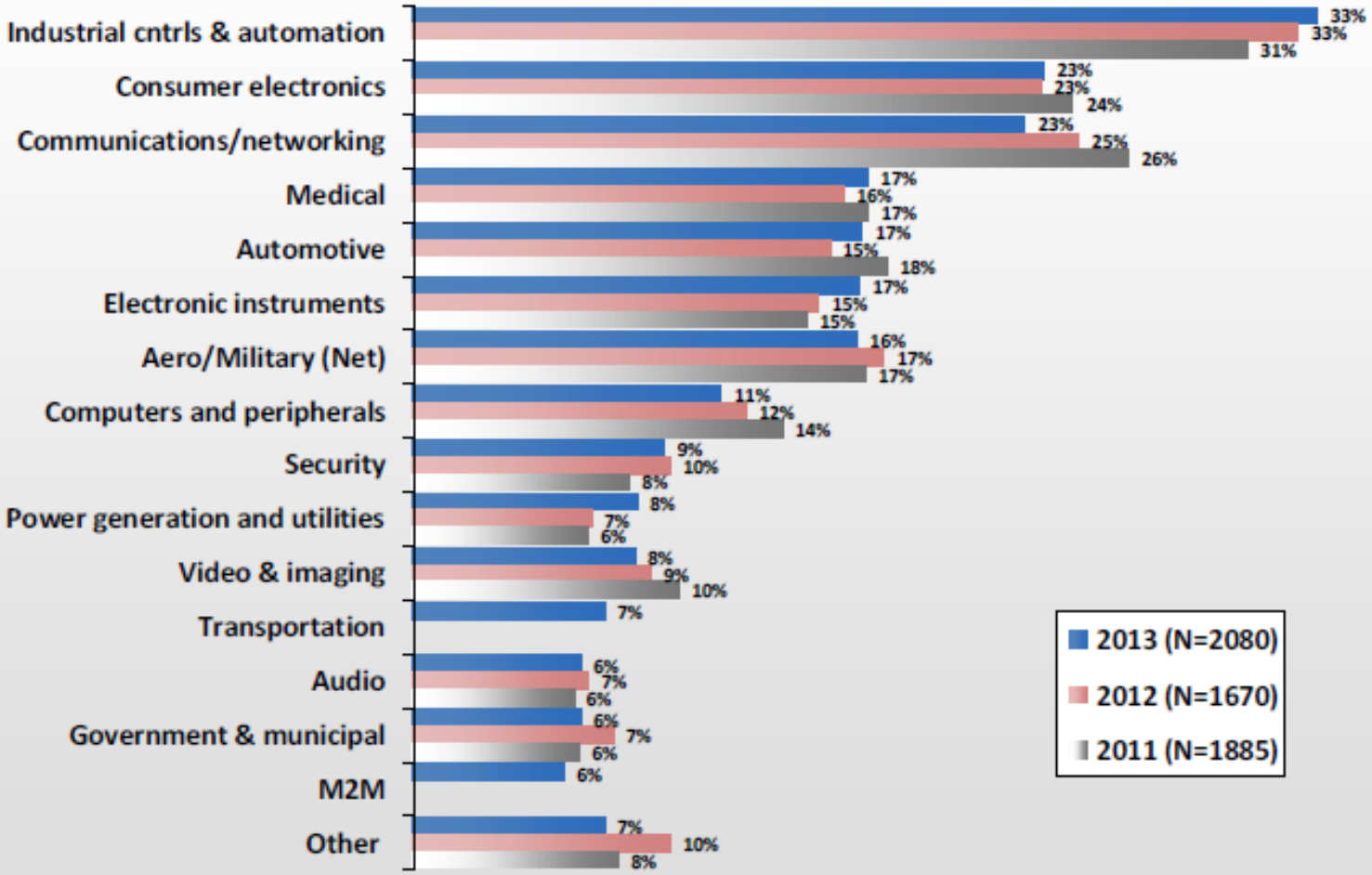
My job function includes:



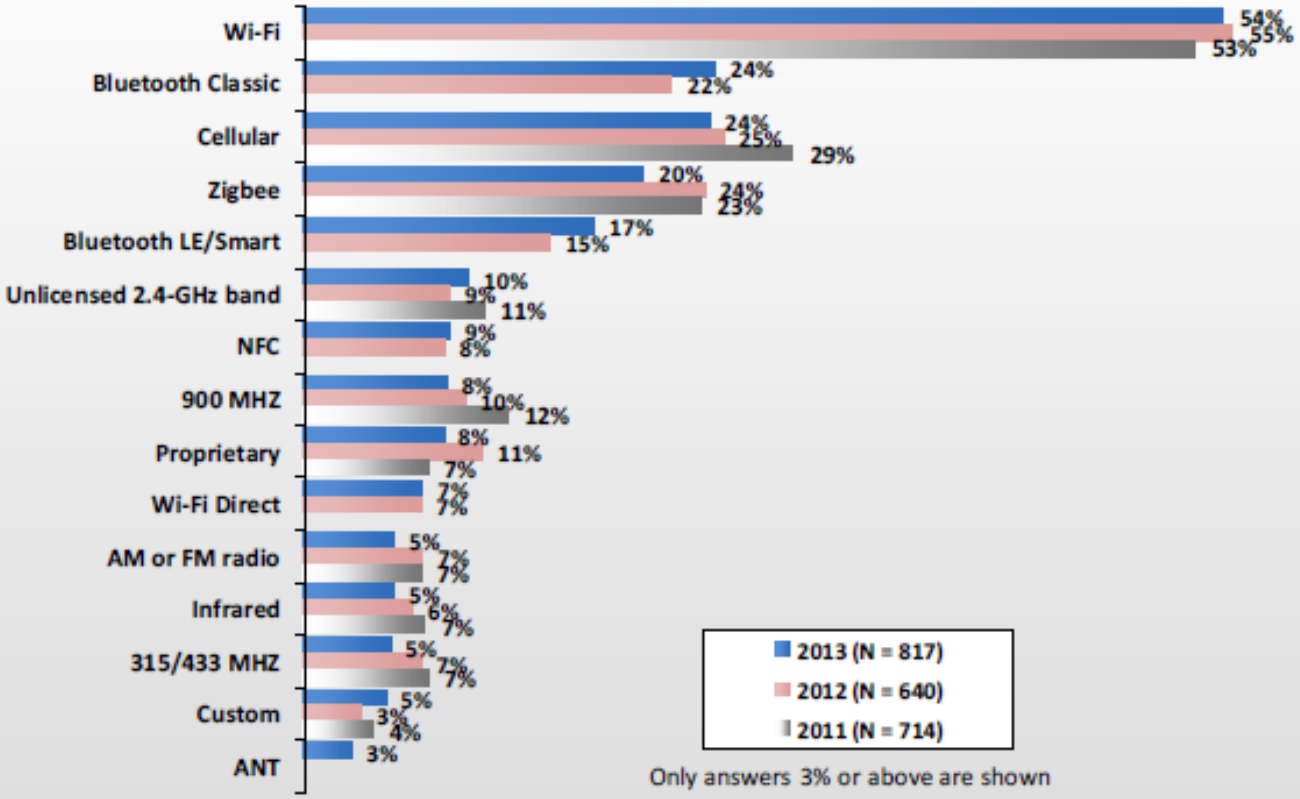
2013: Average number of years out of school = 19.7 years

2013 (N = 2,020)

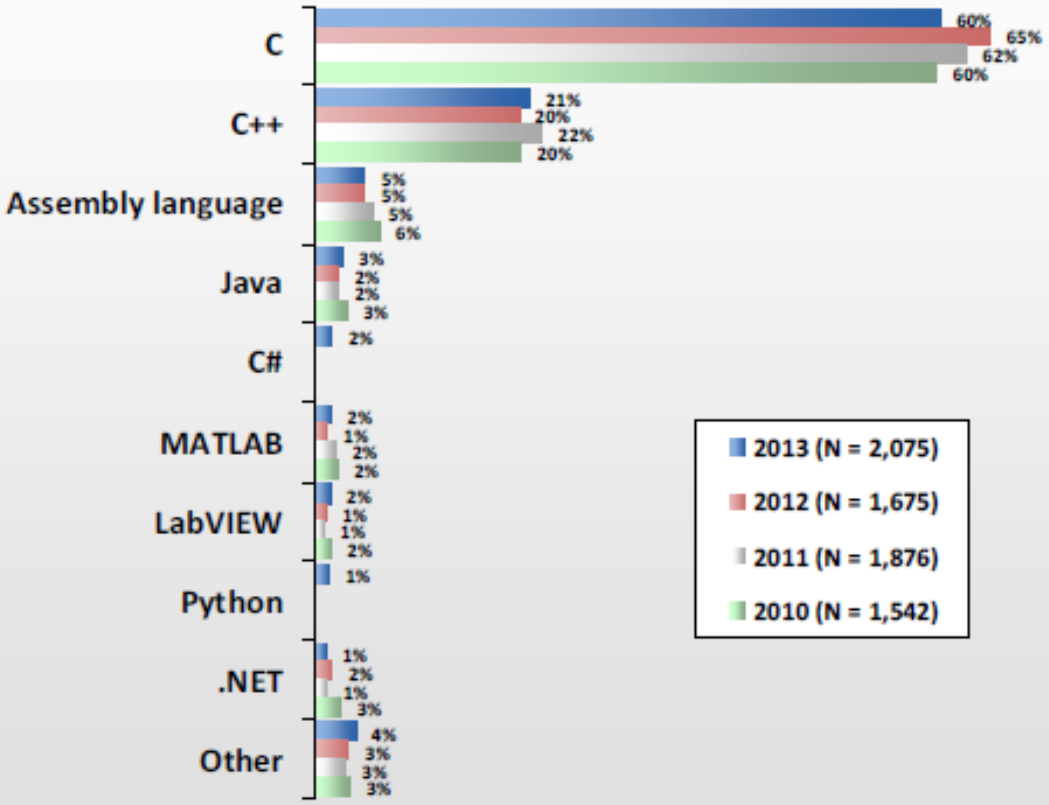
For what types of applications are your embedded projects developed?



If wireless, what wireless interfaces does your current embedded project include?

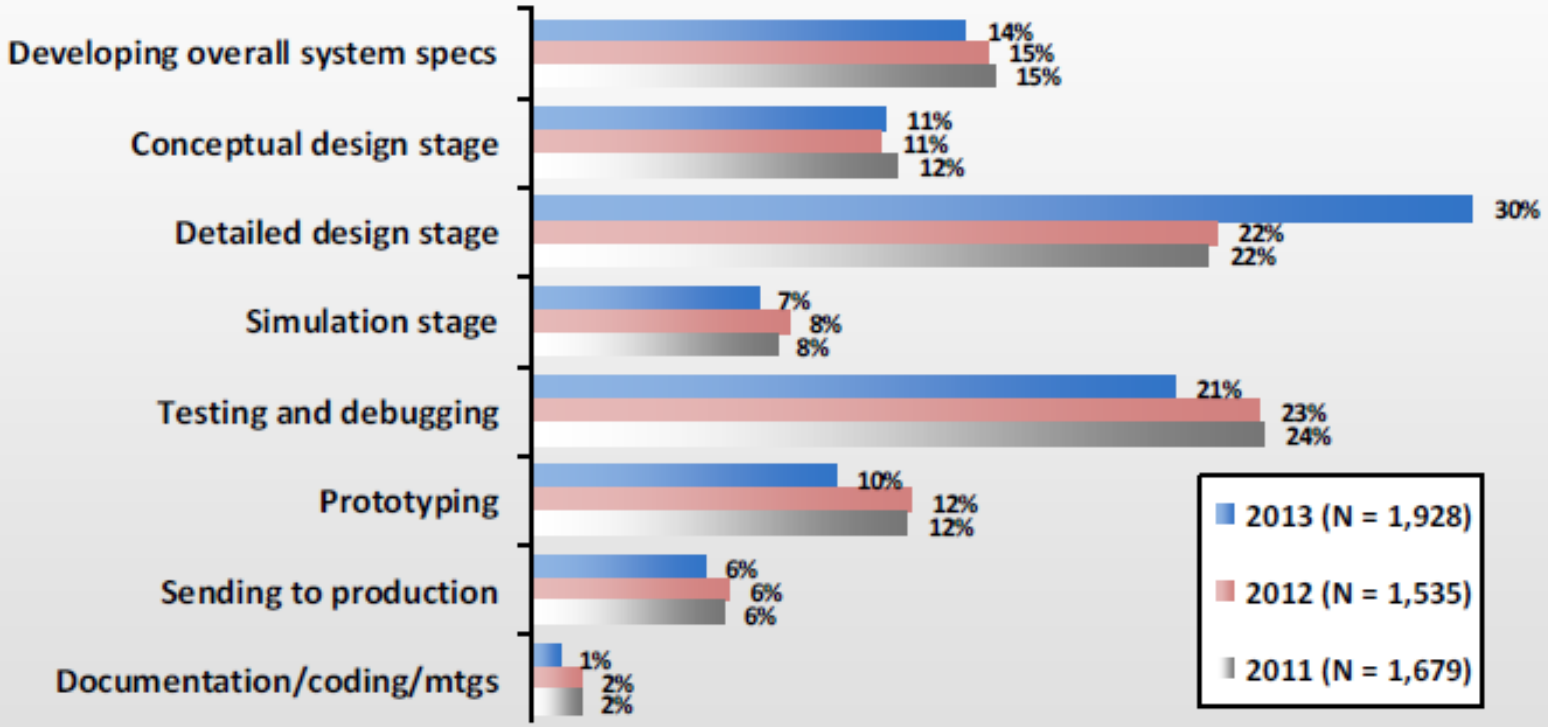


My current embedded project is programmed mostly in:

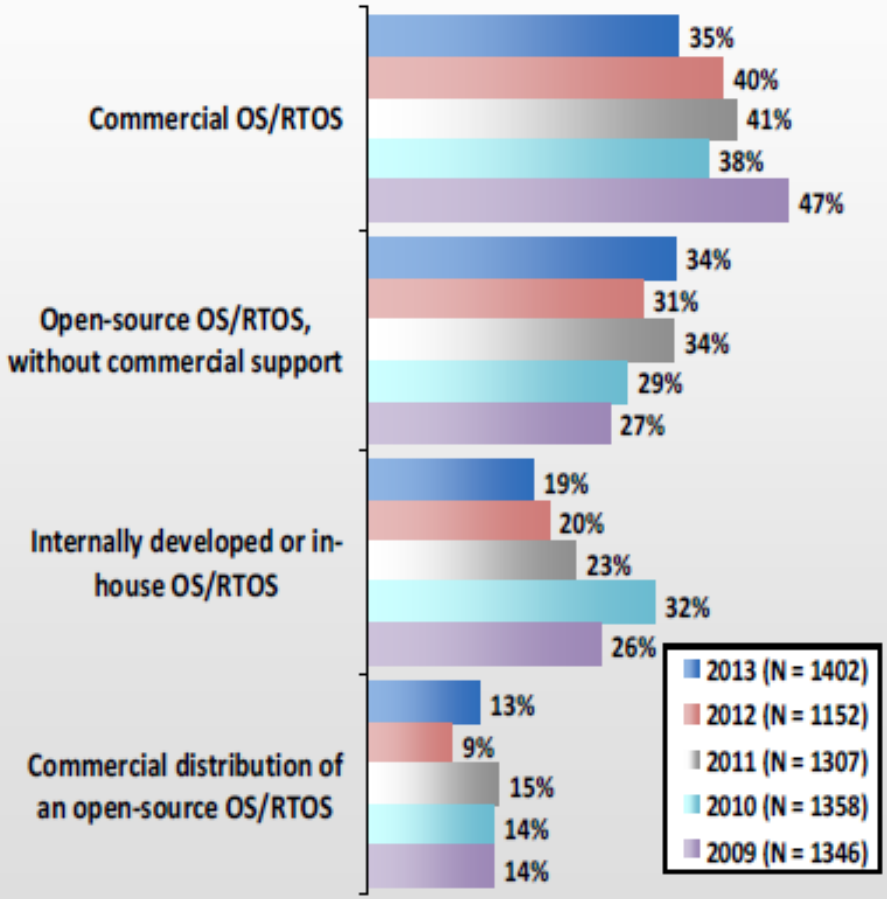


Note: C#, Python and Ada were added in 2013. Ada was under 1%.

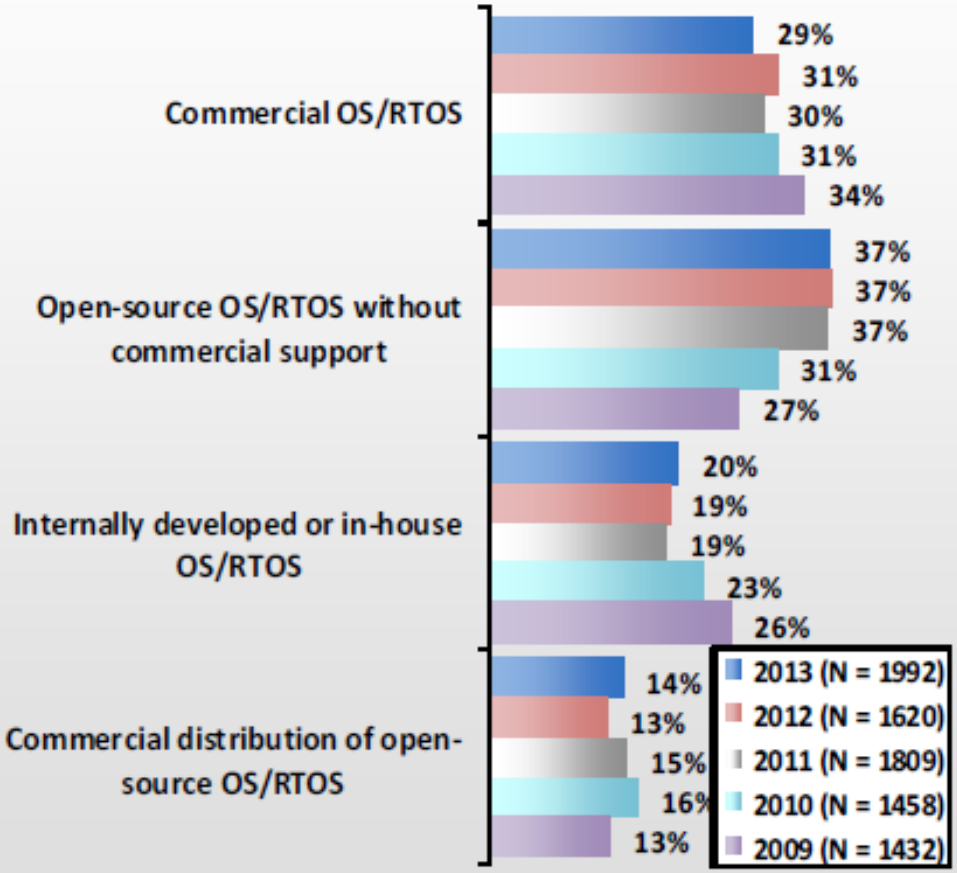
What percentage of your design time is spent on each of the following stages?



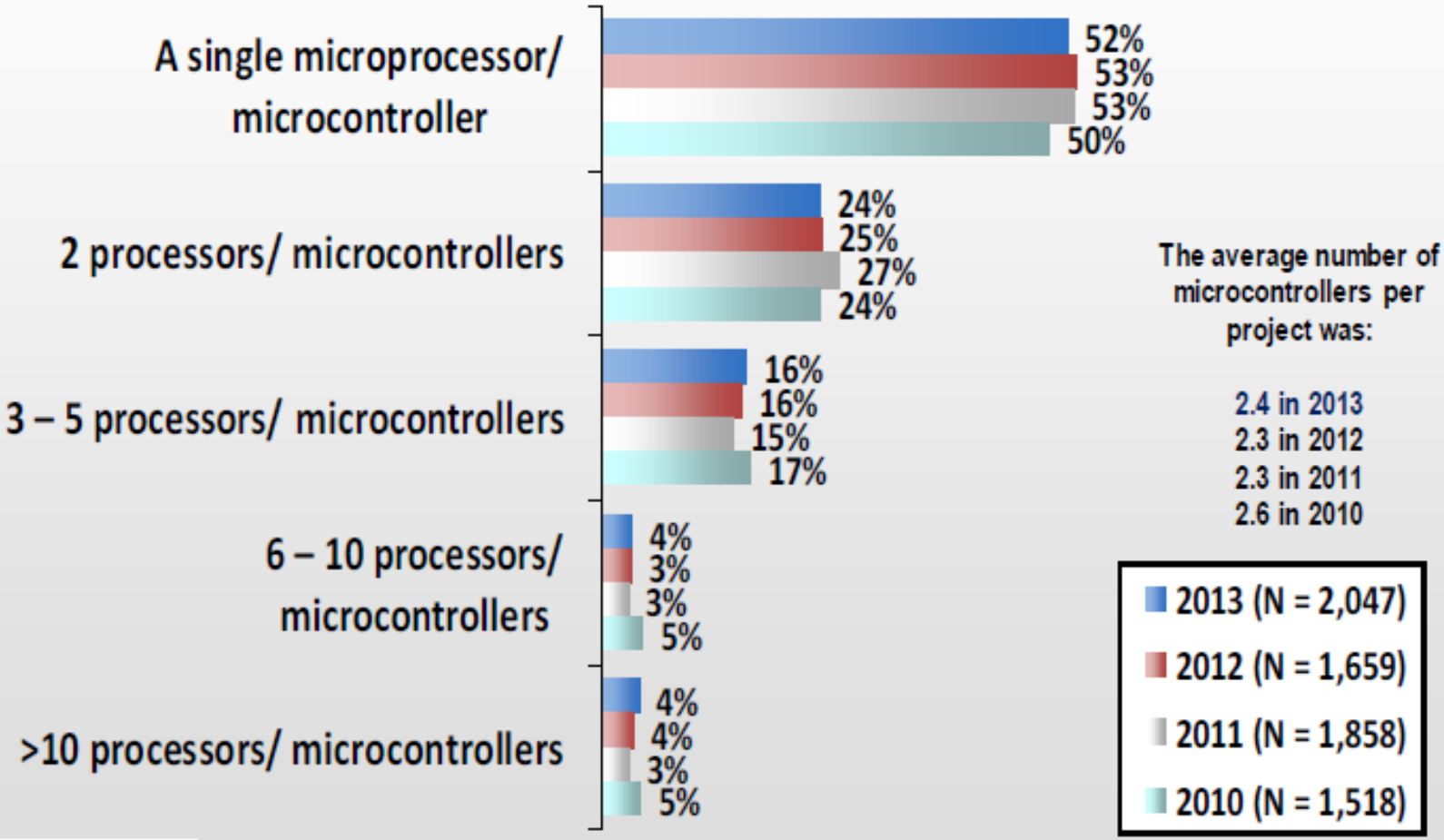
My current embedded project uses:



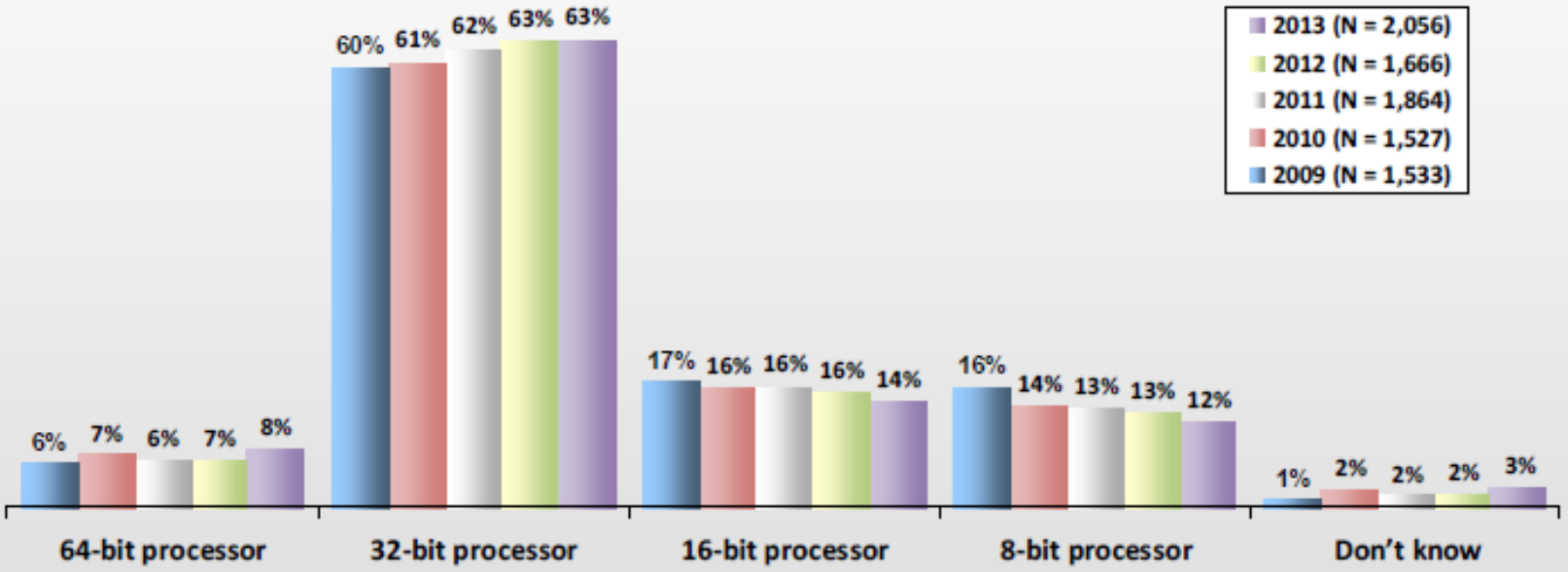
My next embedded project will likely use:



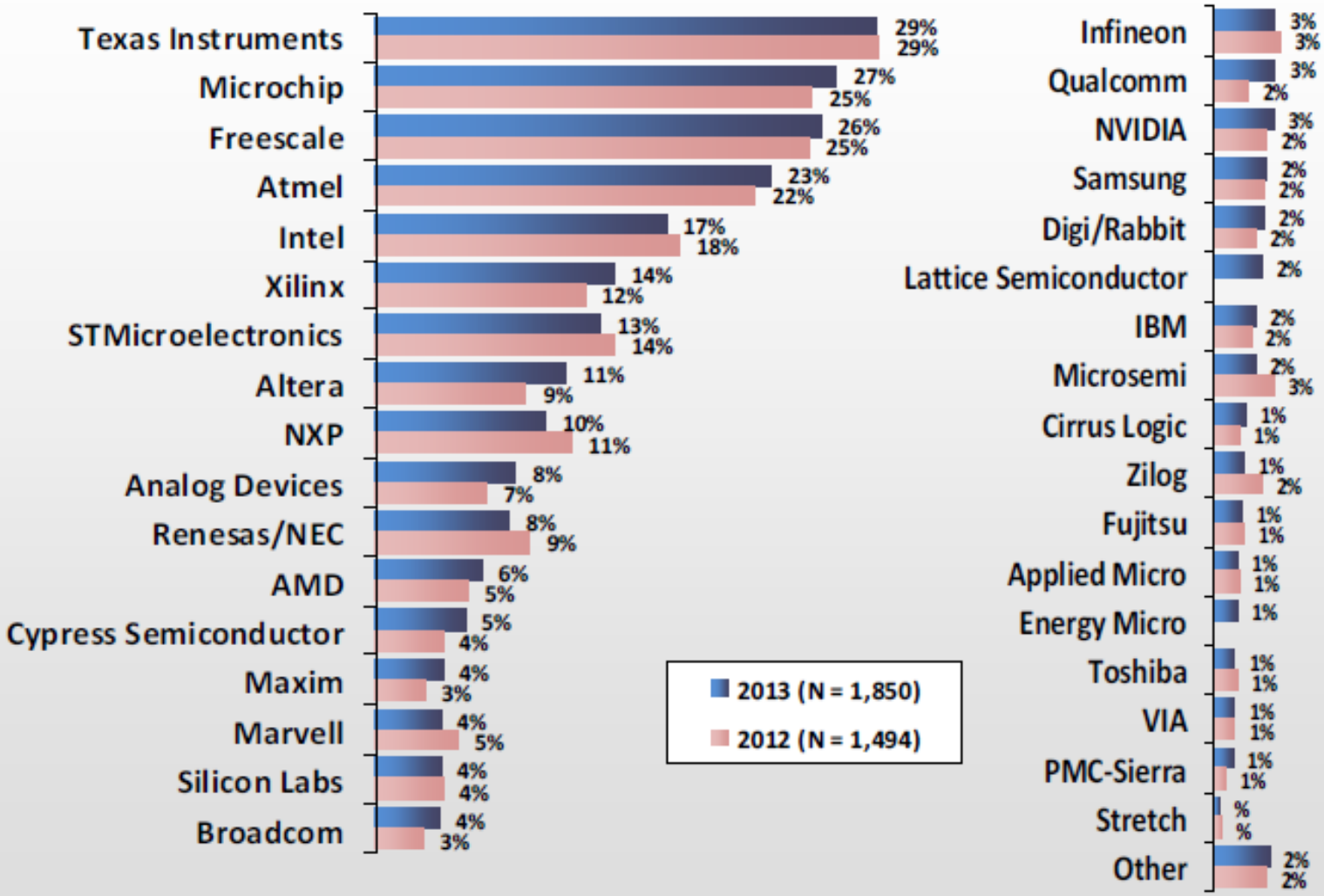
My current embedded project contains:



My current embedded project's main processor is a:

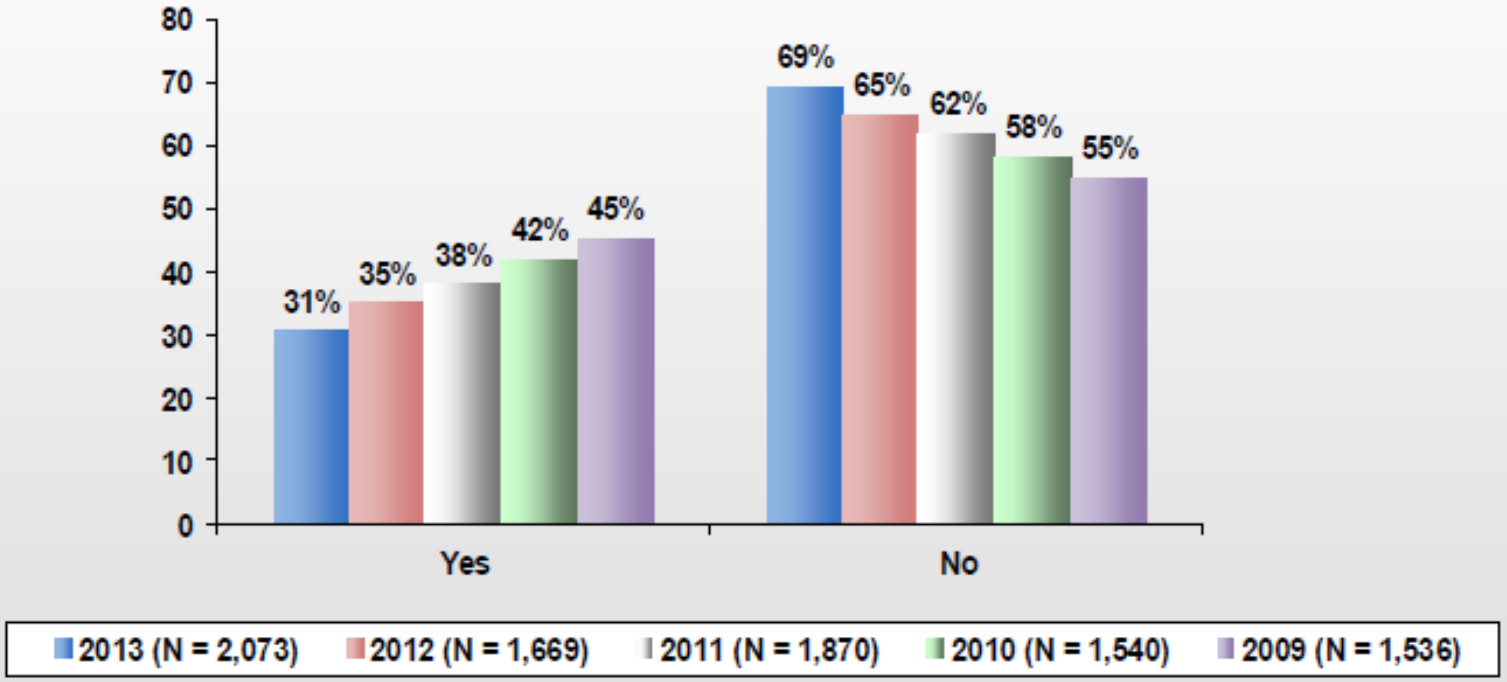


Please select the processor vendors you are currently using.

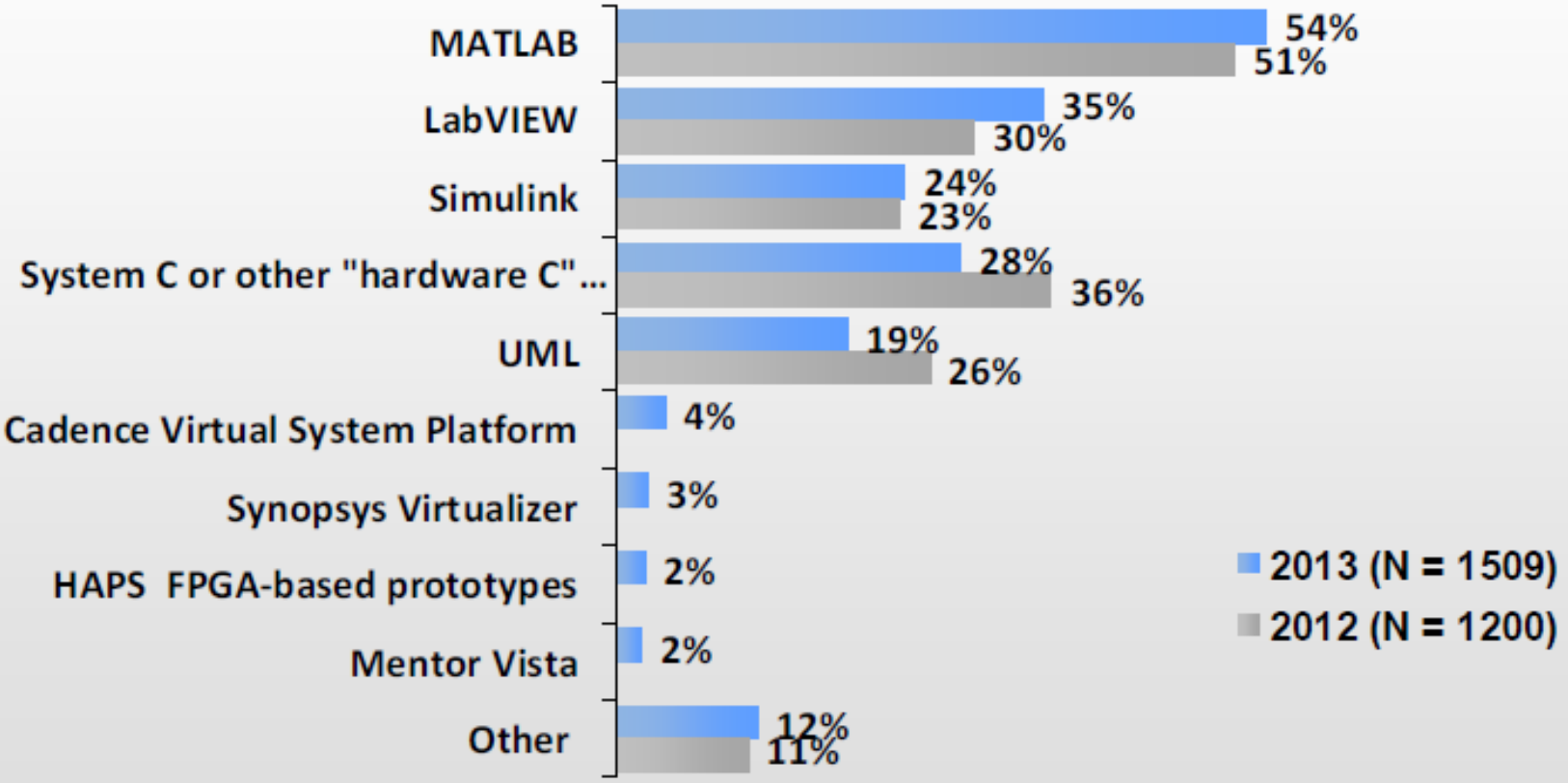


designwest
April 22-25, 2013
McEnery Convention Center
San Jose, CA

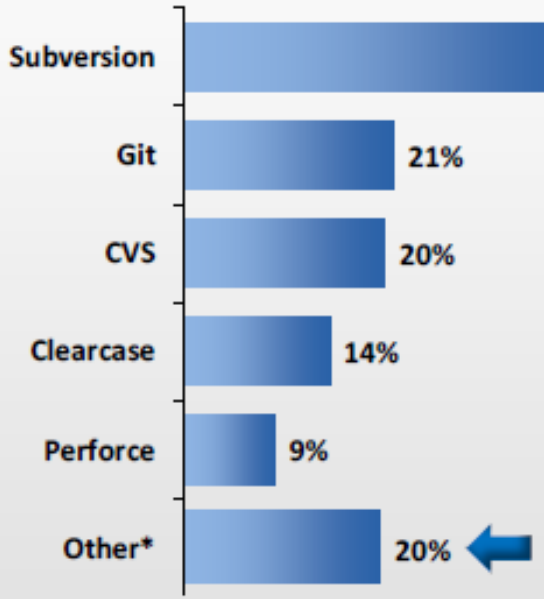
Does your current embedded project contain FPGAs/programmable logic?



What system level design tools do you or your organization currently use?



Which of the following Version Control software systems do you currently use?



2013 (N = 1,660)

*Other mentions	
Mercurial	38
Serena PVCS	23
Microsoft Source Safe	21
MKS	18
Team Foundation Server (TFS)	16
Tortoise	16
Visual SourceSafe	12

Part 3: Embedded Systems at UNC Charlotte

The Embedded Systems and Autonomous Vehicle Lab has a long history of university/industry collaboration with companies like:

- Emerson
- Electric Power Research Institute (EPRI)
- Frontline Test Equipment
- iRobot
- National Instruments
- Zapata Engineering

Graduated students currently work in embedded systems jobs at Qualcomm, Texas Instruments, Intel, General Dynamics, iRobot, Seagate, and The Mathworks.

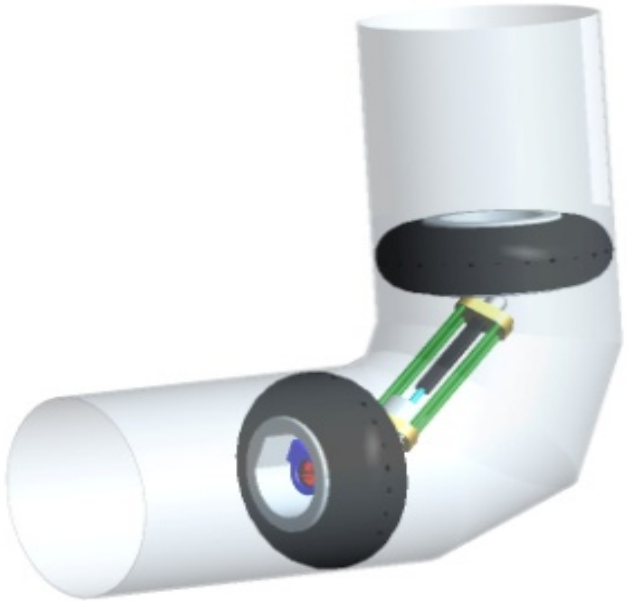
Areas of Expertise

Microcontroller/microprocessor-based systems design (TI, Atmel, Renesas, Microchip, Cypress, Xilinx, others)

Embedded systems software development and testing

Sensor development and use, including wireless sensor networks

Autonomous robotics – design, assembly, sensing, actuation, control, and path planning



Resources

500 square-feet of indoor lab space, 500 square-feet of garage lab space, two Faraday cages

Computing systems and software compilers

Microcontroller/microprocessor development boards

Sensing, actuation and wireless devices

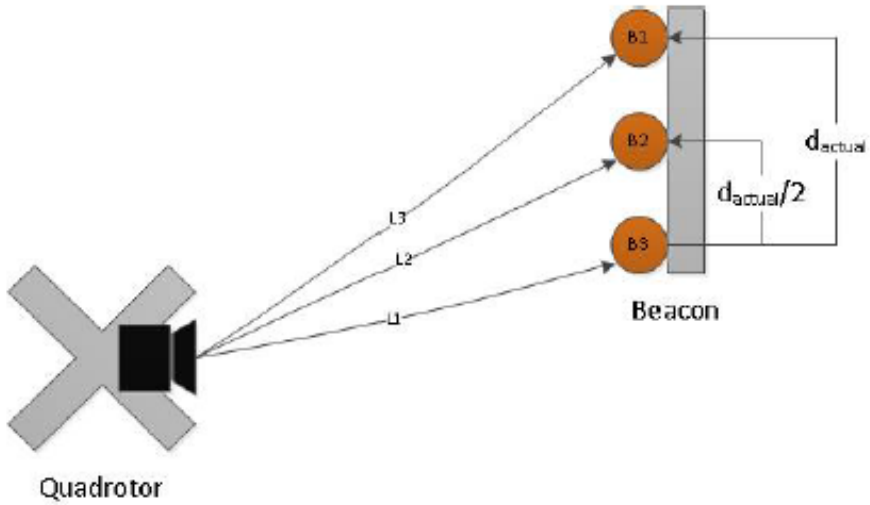
Prototyping machines and tools (board etching/milling machine, commercial soldering stations, drill press, jigsaw, 3-D microscope)

Mobile robotics platforms (commercial: National Instruments DaNI robots, GEARS vehicles, iRobot Roomba and Creates, quadrotors; custom: pipe-crawler, tele-presence, wheeled).

Autonomous All-Terrain Vehicle (Honda FourTrax ATV)

Examples of Graduate Courses

- Embedded Systems
- Advanced Embedded Systems
- Reconfigurable Computing
- Advanced Reconfigurable Computing
- Real-time Operating System
- Advanced Digital System Design
- VLSI System Design
- Wireless Sensor Networks
- Mobile Computing Applications
- Introduction to Autonomous Robotics



Current Projects

- Autonomous All-Terrain Vehicle steering and object avoidance.
- Investigation of spatially dynamic lighting systems
- Adaptability to variations of renewable energy in large scale rechargeable wireless sensor networks
- Quadrotor swarm applications

Your Actions – Investigate Embedded Systems

Like any other skill, you need to practice to get better:

- Purchase an embedded development board (many low-cost, including TI MSP430 Launchpad, Renesas Sakura)
- Download free development tools (Integrated Development Environments – IDEs)
- Practice interfacing sensors, controlling actuators, using operating systems

Like any other technology, you must continue to learn to ensure your skills are current:

- Read, watch video, attend webinars, attend conferences, take courses

Available Resources

Videos on embedded systems: YouTube channel stiquitojmconrad

Free books and educational materials: http://jamesconrad.com/EducationalMaterials/index.html

What we have covered

- Embedded system – application-specific computer built in to a larger system or device
- Embedded systems improve upon the performance, fuctions and features while lowering the cost and increasing the dependability of a system
- With embedded systems sophisticated controls can be added to systems by using low-cost microcontrollers running custom sofware
- Over the past five years trends point to more complex systems are being developed
- UNC Charlotte is an active research and education institution

IUCEE Speaker

Dr. Conrad has visited India on behalf of IUCEE to conduct two week-long workshops on Embedded Systems.

Dr. Conrad is available fall 2014 to visit India again

Possible topics are at: http://iucee.com/fli/2014-flis/

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References

[1] http://www.embedded-vision.com/sites/default/files/technical-articles/Altera/Fig1_hires.jpg

[2] http://www.codeproject.com/KB/mobile/EMBEDDEDSYSTEMSP1/FIG_01.jpg

[3] http://pleasantonautorepair.net/wp-content/uploads/2009/11/check-engine-light1.jpg

[4] http://www.texample.net/media/tikz/examples/PNG/control-system-principles.png