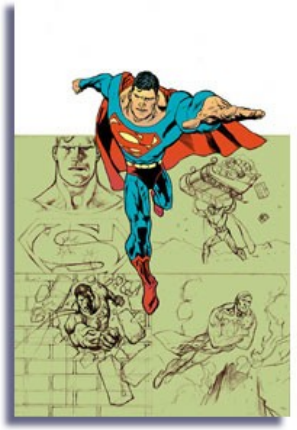


IPRO358 : Low-Cost Robotic Controller

InteRactive RoboticControllers

The Corporation for the next century in Robotics and Handheld Computers!!!

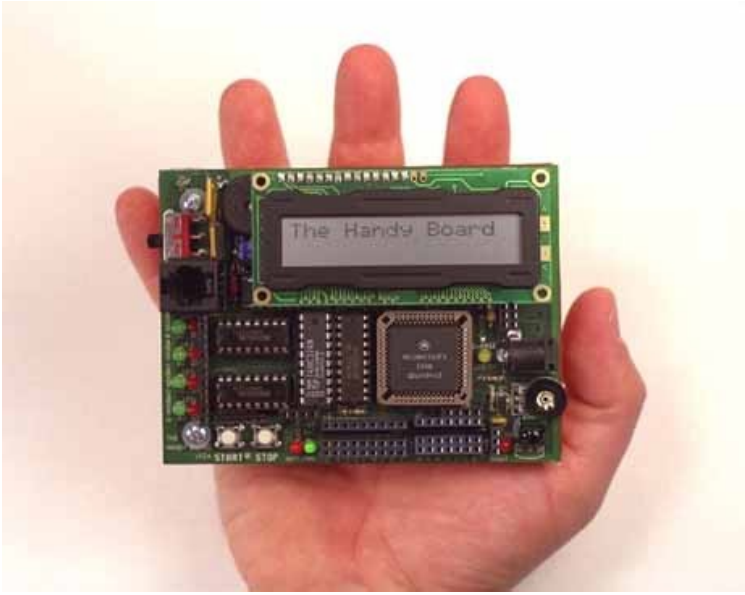
http://www.ece.iit.edu/~irc

Outline

- Introduction
- Low-Cost Robotic Controller
- Interactive Robotic Corporation
- Conclusion

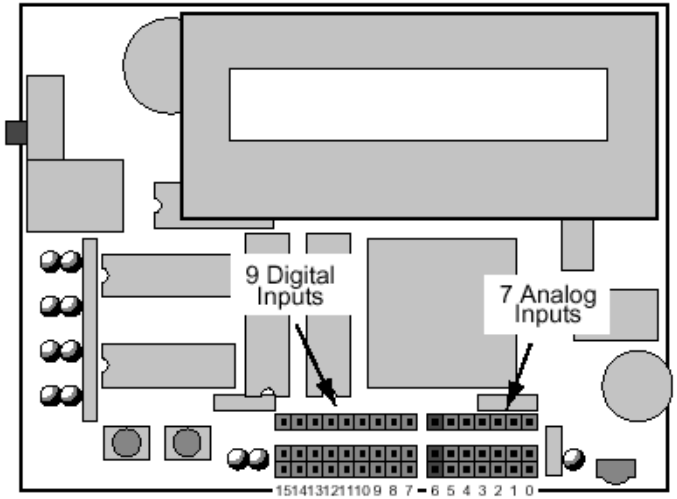
The Competition

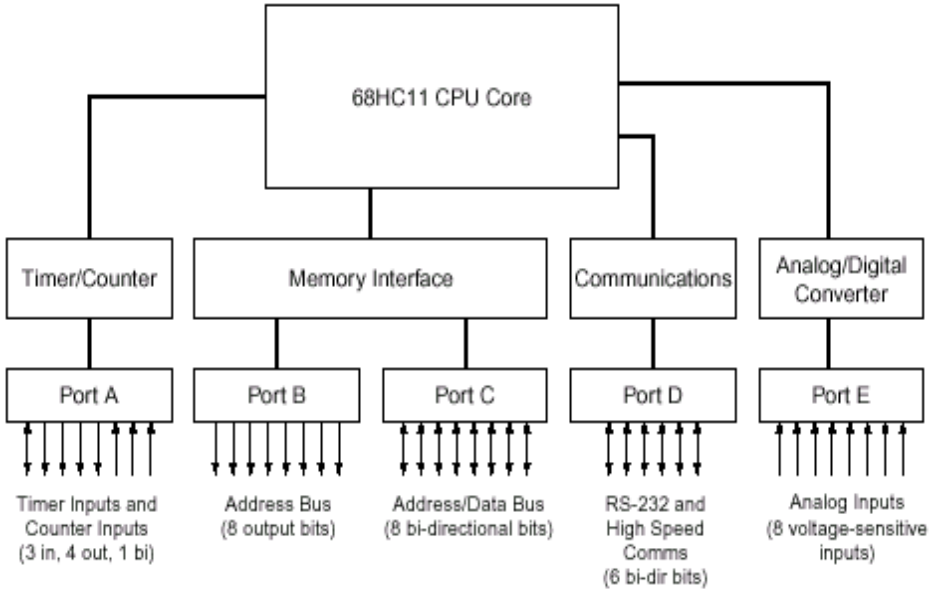
- **The Handy Board:**
  - Designed by an MIT graduate students in 1995, the Handyboard has evolved little since then.
  - Motorola 68HC11 8-bit microprocessor
  - 32K main system memory, battery-protected (allows the use of Interactive C)
  - Output drivers for 4 DC motors (9v, 1A)
  - Inputs for analog and digital sensors; up to 7 analog sensors and 9 digital sensors
  - Internal, rechargeable battery pack (in case)
  - LCD screen (16 character, 2-line liquid crystal display screen)



68HC11 Architecture

Handy Board's Sensor Input Banks



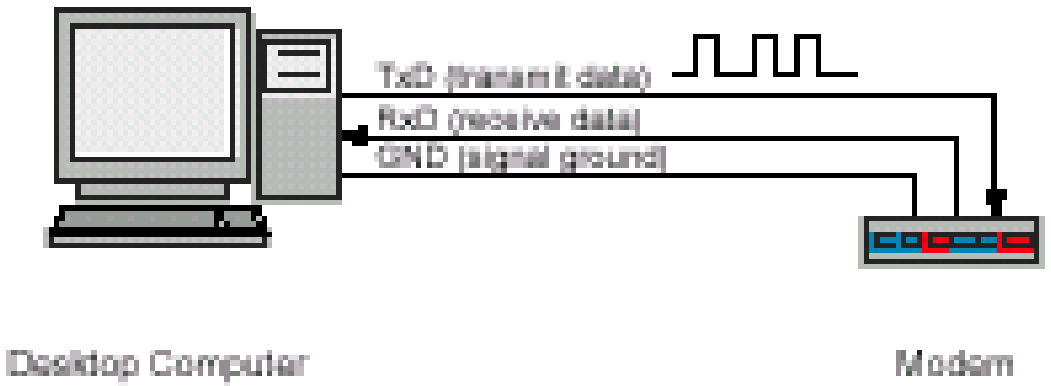


Handy Board has two banks for sensors:

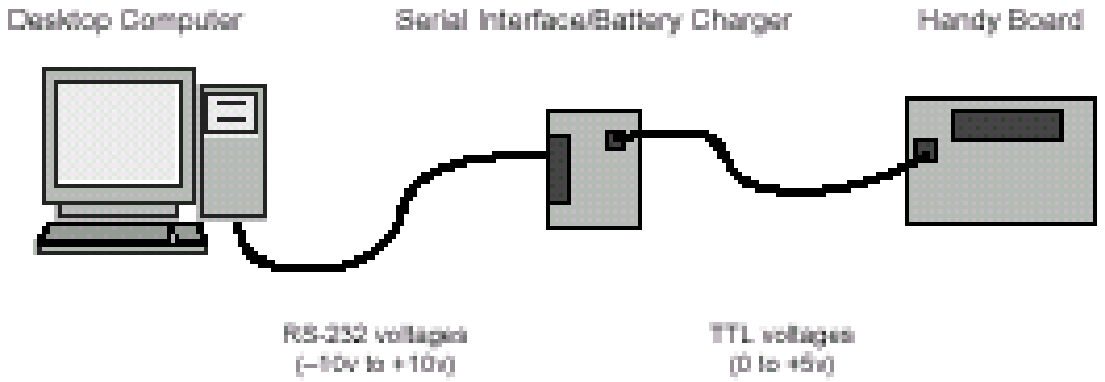
- **Digital inputs**, numbered 15 to 7 on the l
- **Analog inputs**, numbered 6 to 0 on the right

Serial Line Circuit

- HB communicates with host computer over RS-232 serial line
- RS-232 standard comm protocol
  - TxD, transmit data
  - RxD, receive data
  - GND, signal ground
  - *Baud rate* = bps transmitted



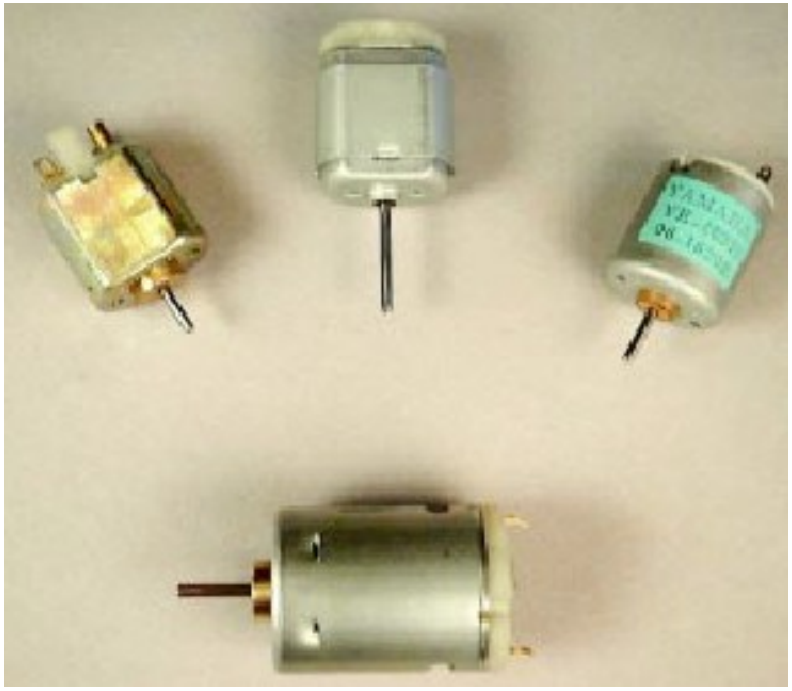
- Serial Interface/Battery Charger board performs voltage conversion



DC Motors

Direct Current (DC) Motors:

- Small, cheap, reasonably efficient, easy to use, ideal for small robotic applications
- Converts electrical energy into mechanical energy
- How do they work?
  - By running electrical current through loops of wires mounted on rotating shaft (*armature*)
  - When current is flowing, loops of wire generate a magnetic field, which reacts against the magnetic fields of permanent magnets positioned around the wire loops
  - These magnetic fields push against one another and the armature turns

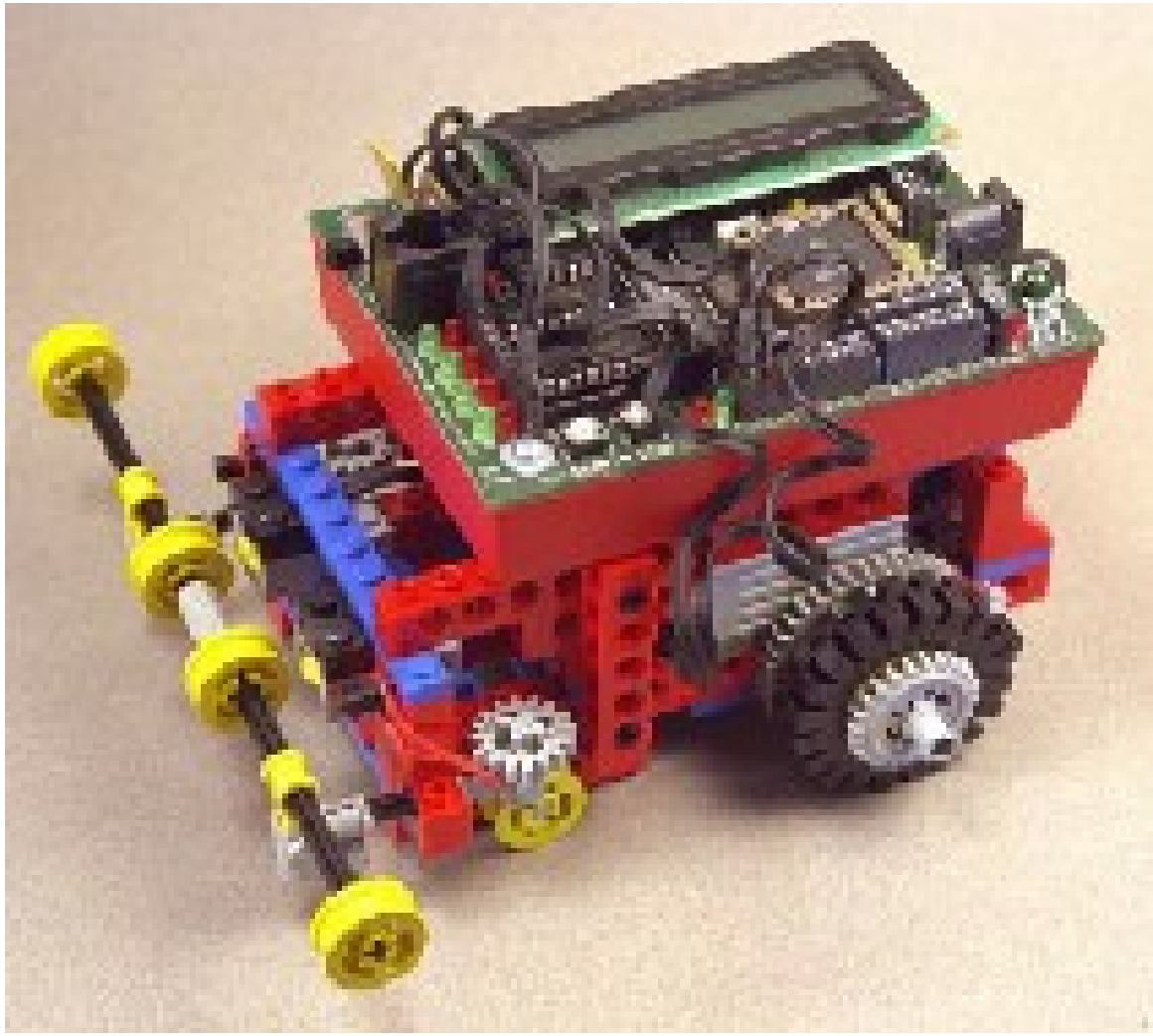


- Efficiency
  - Various limitations, including mechanical friction, cause some electrical energy to be wasted as heat
  - Toy motors: efficiencies of 50%
  - Industrial-grade motors: 90%

Lego Bot

The HandyBug

- HandyBug
- Motorola 68HC11 MCU (microcontroller) to controll motors!
- Program with Compiler called Interactive C



Problems with Handyboard

•Bulky, out of date, and expensive, the Handyboard is not in favor with many University laboratories.

•High power consumption and poor recharge capabilities.

•Programming platforms limited; computer interface unnecessarily complicated and not user friendly.

•Expensive; not affordable for most college students and hobbyists; very little marketing in that area (RIDICULOUS PRICE $$$$)

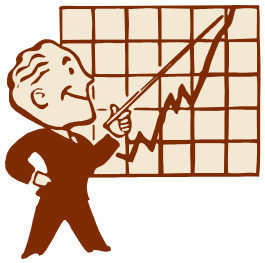
•Lack of protective casing leads to a high probability of static or physical damage

•Not easily mountable onto a robot frame

WHY!!!????

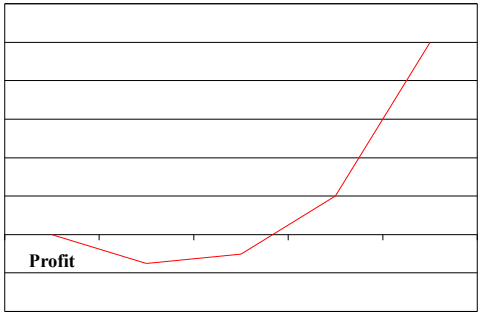
Business Plan

- Business plan to replace HandyBoard with better, smaller, cheaper, and more powerful unit!
- Formed corporation where each IPRO member is actual stock holder:
  - Interactive Robotic Controllers (IRC) LLC
- Papers filed with City of Chicago, Illinois Secretary of State.

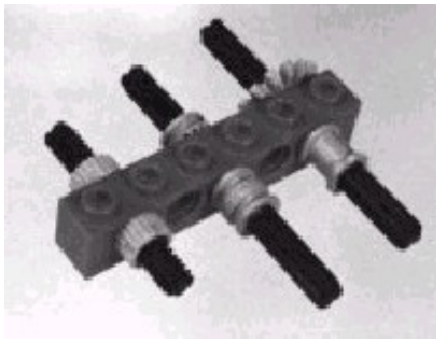


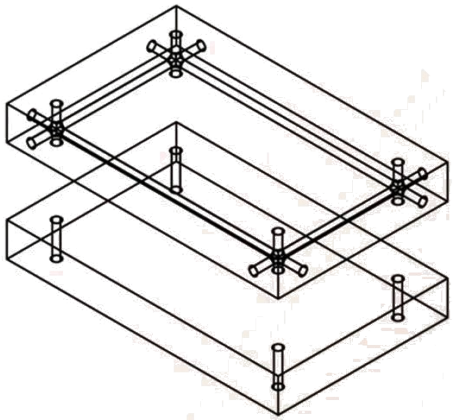
Marketing

- Had marketing consultant visit to give assessment of project status.
  - Joel D. Krauss, MBA
  - Marketing Strategy Group, LLC
- Results
  - Develop Hypothesis testing
  - Questionnaires formed
  - Initiated testbed vendors for beta testing
  - In progress : evaluation of Marketing survey



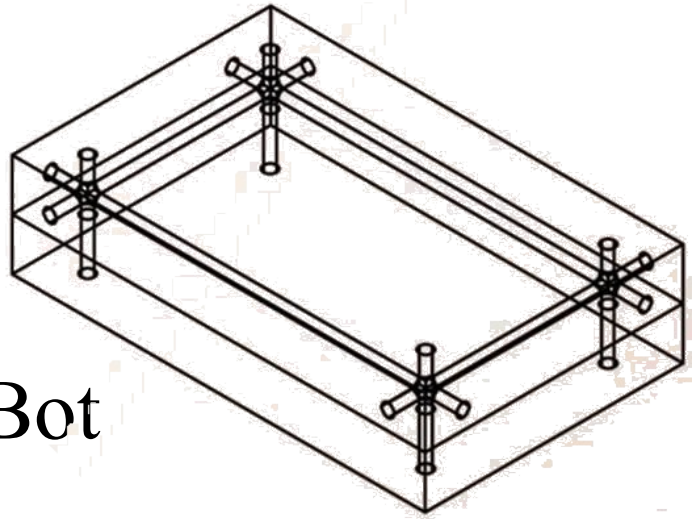
Packaging





- Innovative Design is compatible with a variety of connections:
  - LEGO™
  - K'NEX
- Interchangeable with hobby kits to do robotic explorations.
- Rods allow stabilization of chassis.

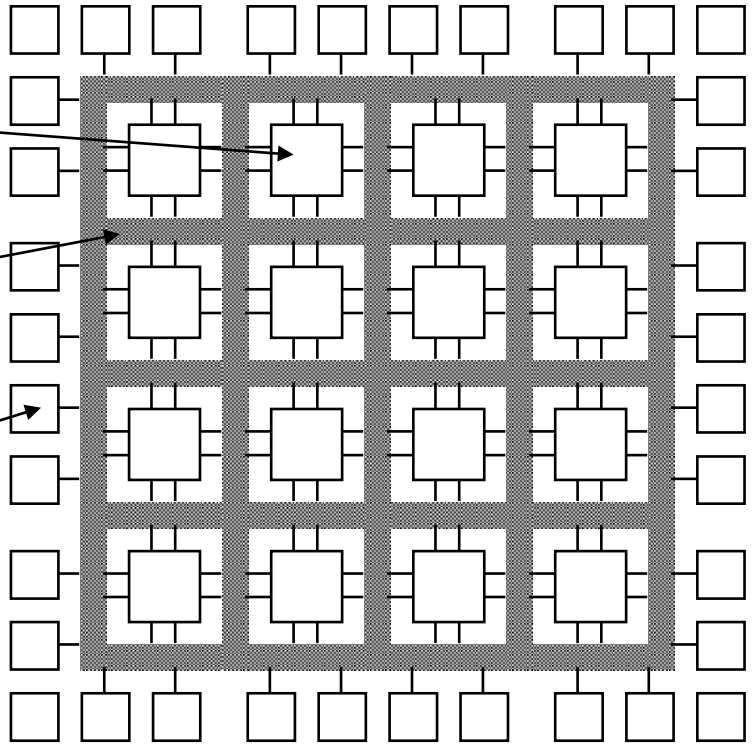
Packaging



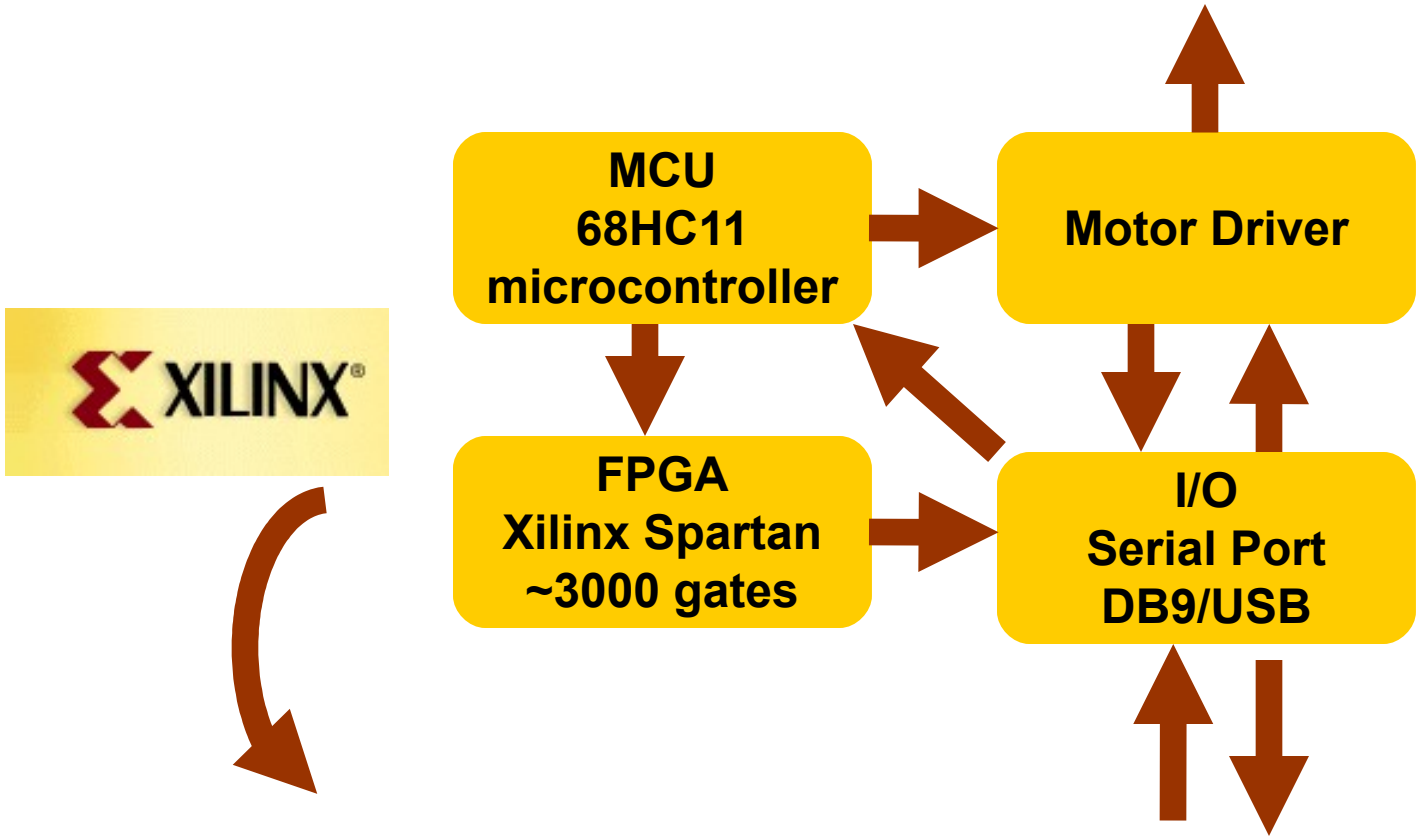
- Serial Connection
  - DB9 connector
  - USB connection
- Interfaced to LEGO™ Bot
- Mr. Thomas Torres
  - MMAE Department Machine Shop Supervisor
- Status: in process of being formed
  - Smaller footprint than HandyBoard

Field-Programmable Gate Arrays (FPGA)

- Logic blocks
  - To implement combinational and sequential logic
- Interconnect
  - Wires to connect inputs and outputs to logic blocks
- I/O blocks
  - Special logic blocks at periphery of device for external connections



Block Diagram



Manufacturing

- Arranged deal with local PCB fabrication facility
  - Create PCB board
  - Assemble board and solder connections
- Motorola donated 68HC1X chips

Bill of Material

- Companies utilize BOM to assess price and set profit margins

Our Cost: $38.27

HandyBoard
Cost: $400

Difference:
$361.73!!!!!!

Part	Cost
Xilinx Spartan FPGA	$5.56
LCD Display	$15.46
68HC11 MCU	$3.50
Motor Controller	$1.50
Caps, Resistors, Connectors	$2.50
Board Construction	$9.75

Hardware/Software CoDesign

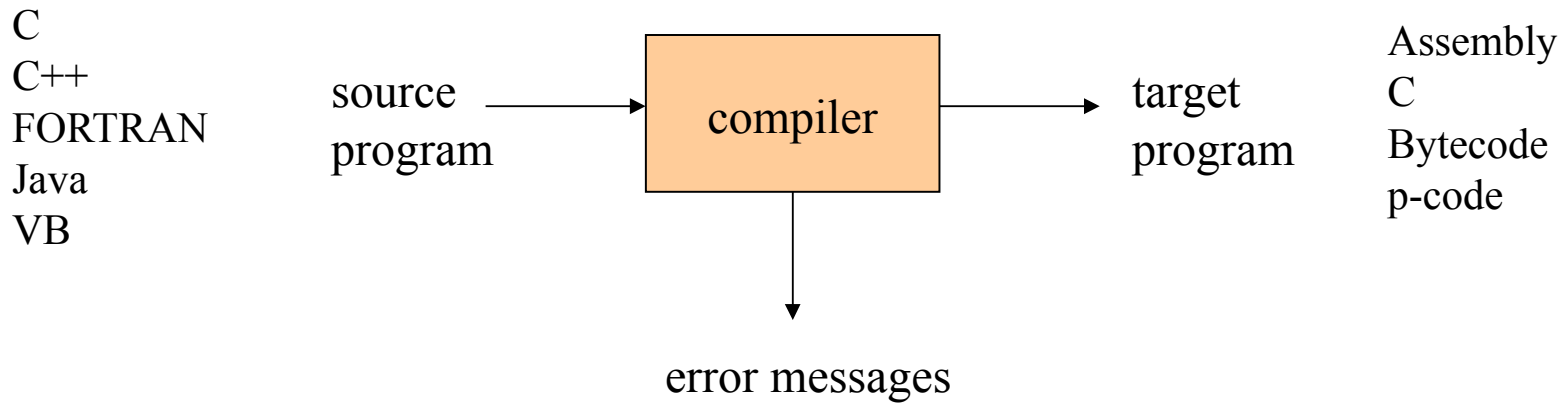
- FPGA can be utilized to redesign hardware to minimize software complexity.
- New equivalent hardware can be easily introduced to achieve new device.
- New designs will be an “Engineer’s PDA”.

Construction of Baseline BOT

- Built baseline robot out of LEGOS to utilize with new board.
- Construction manual to accompany board.
- Price is convenient for students to purchase LEGO + board along with textbook (~$50)
- Testing of board to benchmark testing of several designs

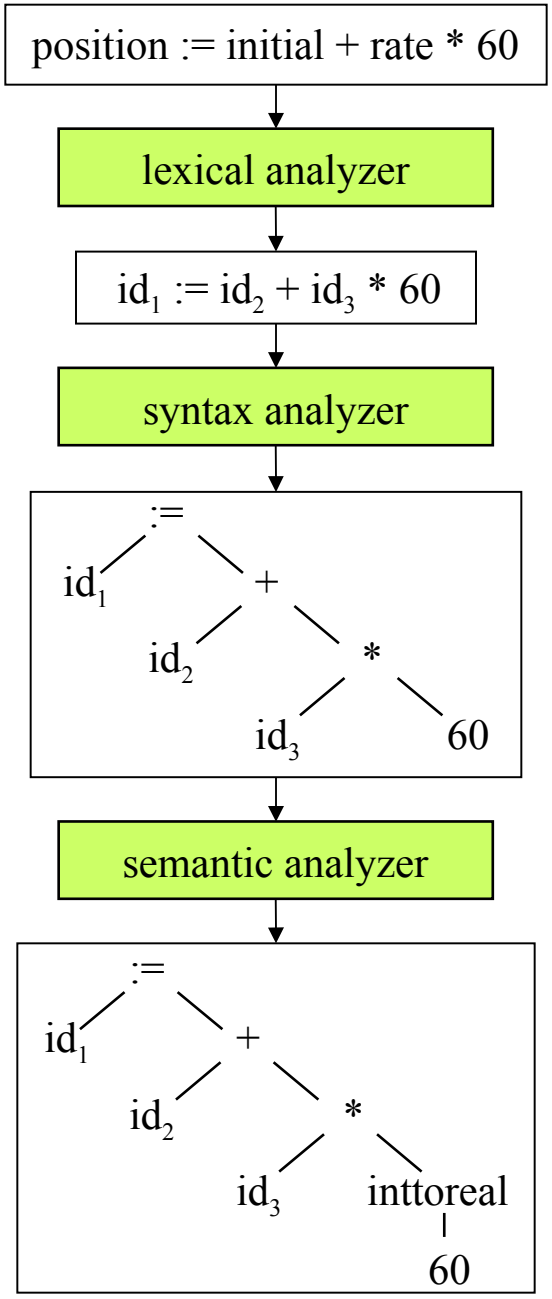
What is a compiler ?

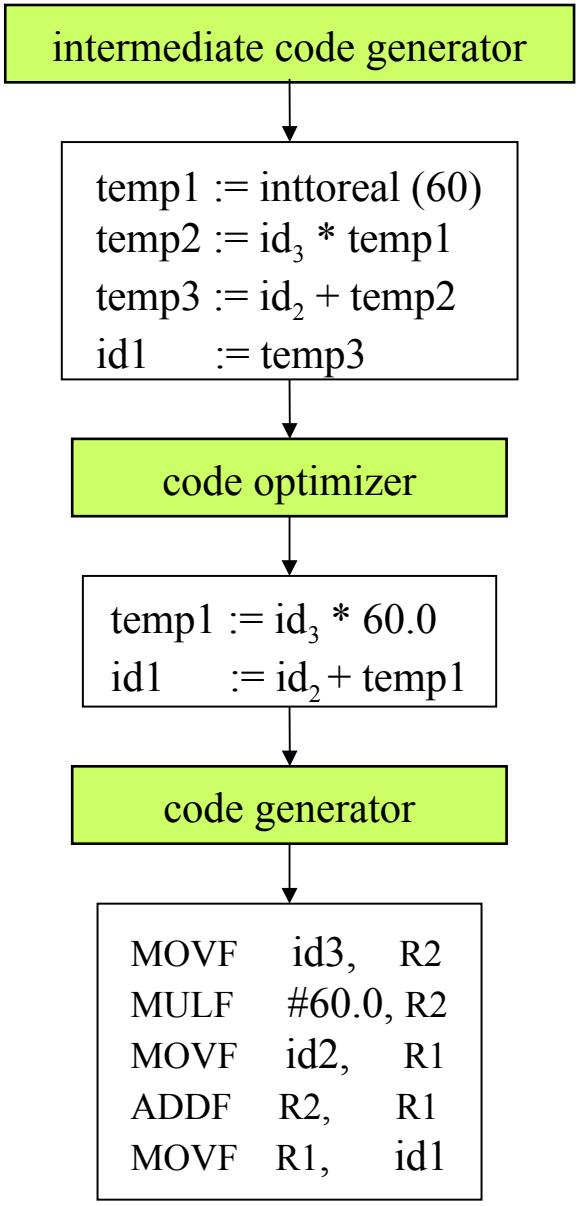
- Translate a “source” program into an “equivalent” “target” program.



- IRC Compiler utilizes free GNU software to compile code
- Better than HandyBoard’s previous compiler in that it provides C and C++ support.

The Phases of a Compiler





Outreach

- **Opened relations with A.J Dimond H.S.**
  - **Free product sample**
  - **Lower education level testing**
  - **Address possible high school market**

- **Work in conjuncture with school science teacher to introduce board to H.S market**
  - **Contact: Mr. Paul Schwartz**
  - **Travel to school – Speak to classes, student science and math organizations**

Market Test

-A large majority of established Engineering programs already operate the Handyboard for entry Electrical Engineering courses.

-Newer programs, such as the new EE department at the University of Alaska Anchorage, have no robotic control systems

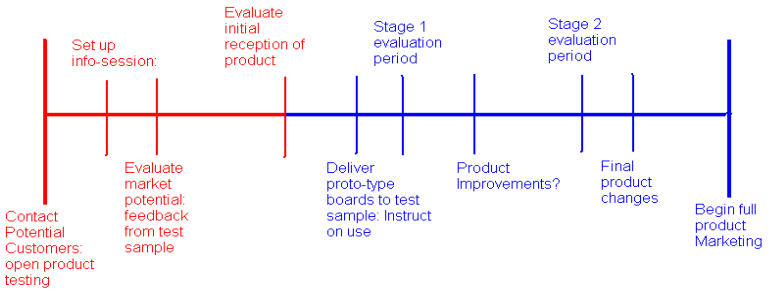
-Students in both systems usually cannot afford a Handyboard for private use.

-A different marketing approach to target these different situations

-(1) Contrast the values of the Handyboard vs. IRC

-(2) Offer incentives and a driven sales strategy to fledgling programs (UAA)

-(3) Maintain a low cost model with a student's price range; market it to engineering hobbyists



Conclusion

- Developed corporation to produce low-cost robotic controller.
- Interactive Robotic Controller, LLC
- http://www.ece.iit.edu/~irc
- New products being manufactured targeted at Universities, hobbyists, and engineers.
- Public-domain software tools!!!
- Powerful, yet small and elegant!