FreeBSD, BeagleBone Black and Robotics

Authorities empowered to control, support and guide endeavours the academic research behind the modeling of Aduka-II

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Presentation's Overview

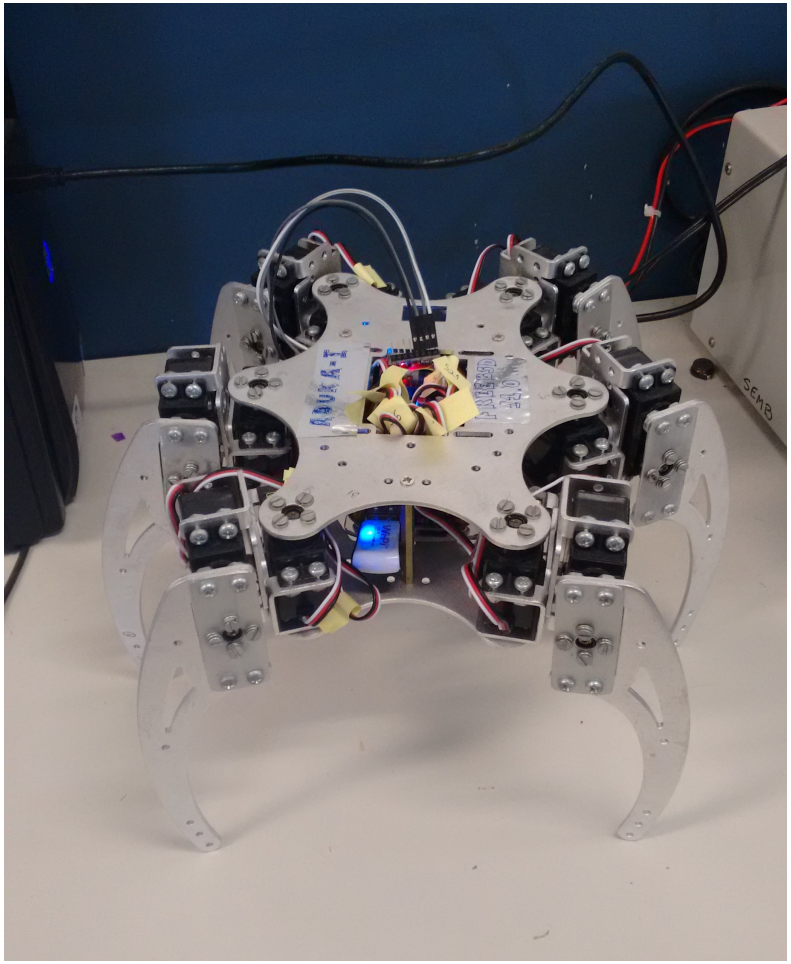
Aduka-II: The Project

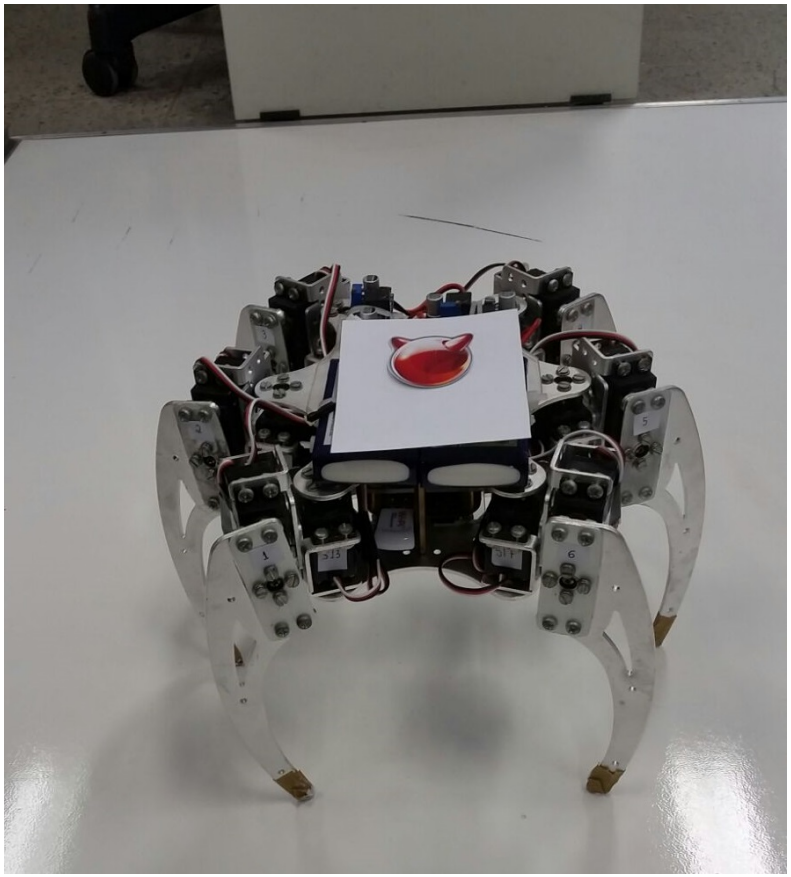
- "Aduka" is a hexapod robot which can be remotely controlled;
- Aduka-II is the second (and current) version of this hexapod robot;
  - It all started in a research laboratory with a motivation to create an innovative project for embedded systems related to the educational field of robotics; it was Aduka-I.
- Since its very first version we went out of any "comfort zone";
  - FreeBSD was getting support on BBB;
  - There was no hexapod at that point running a BSD system;
  - Why not to try to build one?
- The project is being developed at the "Laboratório de Inovação Tecnológica (LIT/IFCE)- Fortaleza - Brazil;
- All material and financial support is also provided by LIT/IFCE.

So, what is exactly this talk about?

- The main idea of this talk is to show the possibilities of developing a remotely operated hexapod robot (Aduka-II, in this case) and its control system out of many researchers' comfort zone.

Aduka-II: The Prototype





System Description

- It is a bioinspired robot;
- It uses single boards to control robot movement;
- It is a ROR - Remote Operated Robot;
- It is powered by FreeBSD 11.0-CURRENT;
  - ... with mix of Python (2.7) and C;
- It provides a server/client application via WiFi (hostapd);
- It controls 12 servomotors via serial communication;
  - ... and here comes our 12 DOF;

Hardware Platform

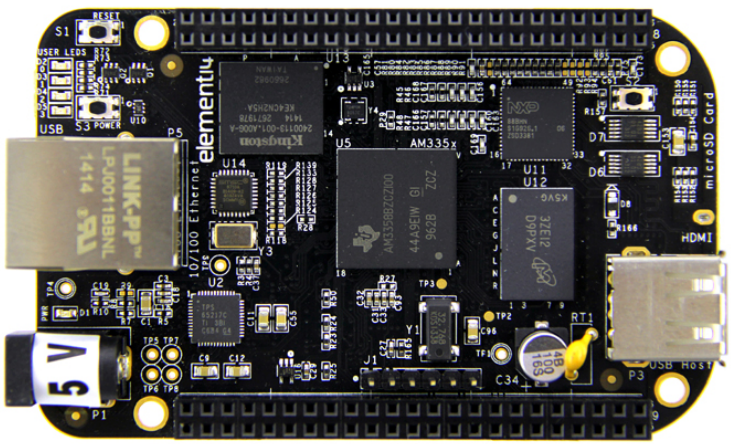
The Aduka II-robot makes the use of single boards, which together compound the hardware platform.

- BeagleBone black (Revision C);
- Servo Motors;
- PWM driver board;
- Batteries;
- Voltage regulators boards.

BeagleBone Black

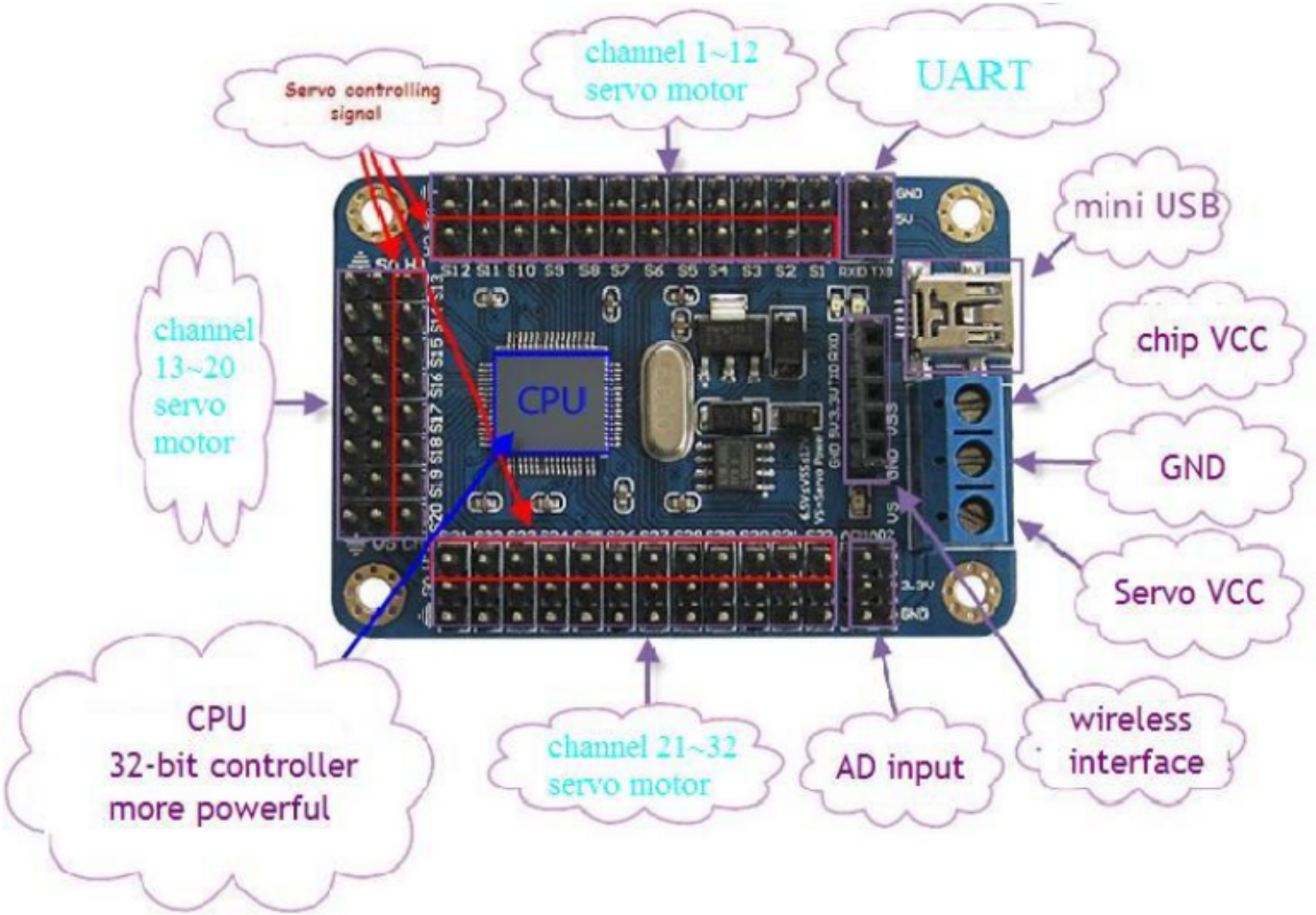
Features:

- The BeagleBone Black is a System on Chip (SoC) board developed by Texas Instruments and is available on the market for embedded systems developers, enthusiasts or hobbyists;
- Wifi support and Serial Comunication;
- Boot from a microSD card;
- Compact size, light weight and low power consumption;
- Aduka-II uses BBB revision C.



Pulse Width Modulation(PWM) driver board

As BBB has only 4 PWM channels, we decided to use a dedicated board to generate the PWM for servo motors.



Comunication Protocol

The two boards communicate using serial 0 (tty0).

Format: # <ch> P <pw> ... # <ch> P <pw> T <time> \ n \ r

<ch> = Servo number, range 1~32 (decimal number)

<pw> = Pulse width (servo position), range: 500~2500. Unit: us (microseconds)

<time> = Time used to move to the position, effective for all servos.

\ n \ r = Binary number 0x0d, 0x0a (carriage return), the command terminator

Servo Motors

Aduka-II has 12 servo motors, two per leg, that support and move the robot in different directions.

Servo motor Futaba S3003

Power Source

DSN2596

To power up Aduka-II there are two batteries, one dedicated to servo motors and other dedicated to power the boards.

Software Platform

The software platform consists of a FreeBSD system running simple custom coded Python scripts to control the 12 servomotors. It also gets the benefits of FreeBSD to serve a small WiFi network between the bot and the client controling it.

Why FreeBSD?

- FreeBSD is known and considered as one of the most robust and secure multi-user and multiplatform operating systems of modern computing;
- FreeBSD is developed by hundreds of high level and recognized engineers, including, but not limited to, BSc., MSc. and PhD. students and professors in various computer science (+engineering) fields;
- FreeBSD supports the largest academic and government backbones in the world;
- FreeBSD serves educational institutions, research, innovation and development foundations or companies around the globe;
- POSIX.1e, TCP/IP, f-root, DC/B3 EAL4, IPv6, ...

FreeBSD on BBB: First Steps

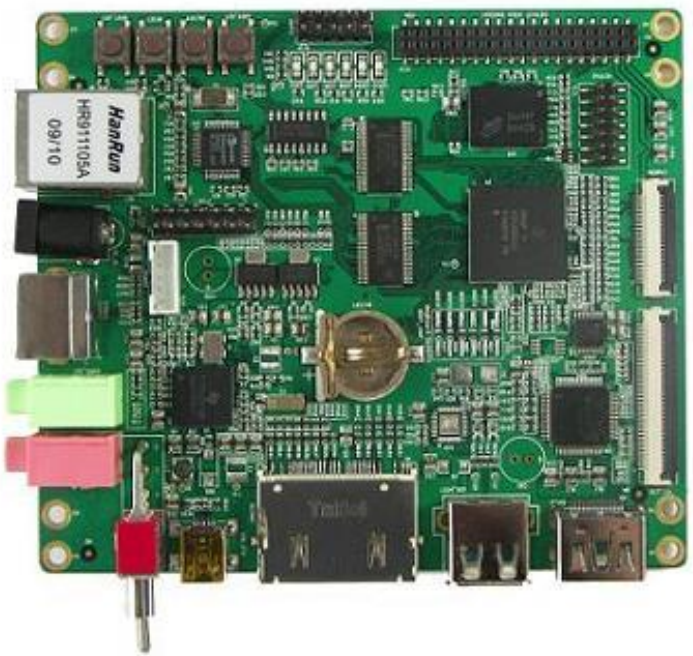
The BeagleBone Black can boot from either the built-in eMMC or a micro-SD card. In this current scenario, Aduka-II still needs a FreeBSD system to be booted from micro-SD. The board was also shared with other researchers in the lab.
To start "Aduka":

- A micro-SD card with an image of FreeBSD for armv6 must be inserted at the BBB;
- The "Boot Switch"button must be pressed and holded (it is the button on the top of the board near the micro-SD slot);
- Power it up, either via a 5v adapter or through a mini-USB cable.

The switch state is recorded by the power chip when power is first applied and will be kept until power is removed.

Packages? Custom Kernel Images?

- Once upon a (sad) time ...
  - Gentoo Linux
  - DevKit8000; OMAP 3530, Cortex-A8
  - BeagleBSD

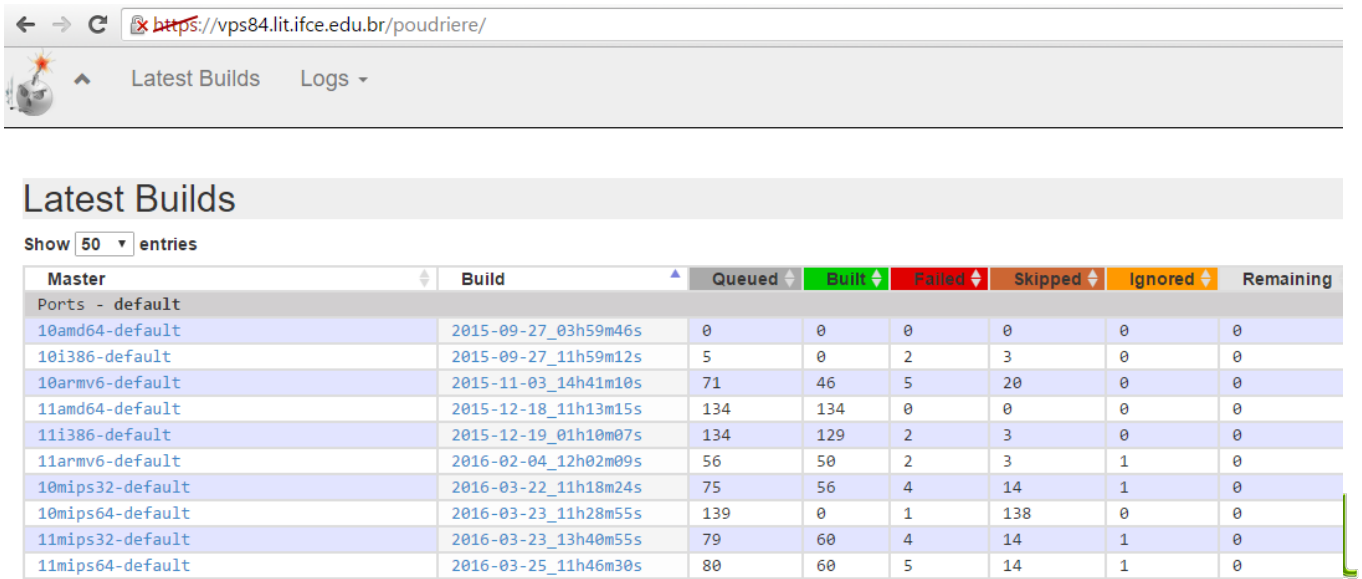


- Now ...
  - Crochet

  - release.sh

Packages? Custom Kernel Images?

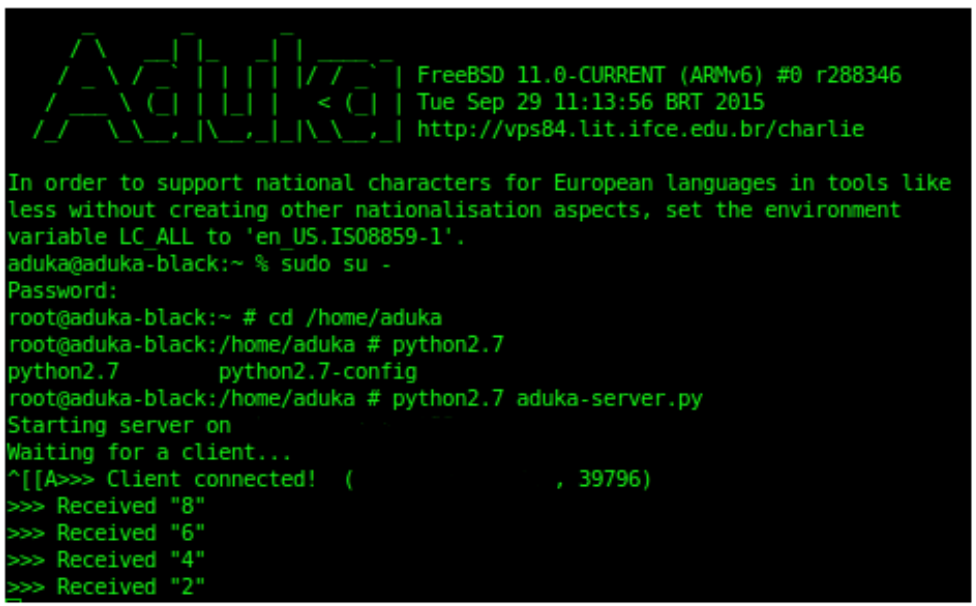
- There wasn't an official repository for ARMv6 packages;
- Get in touch with custom images and packages for ARMv6 would support/help the FreeBSD project too
  - Problem reports (PR) were created; some to base and ports: sys/boot/fdt/dts/arm/beaglebone-black.dts (r287419), #197609, #197332, ...
- Building "Aduka"should also be fun, right?]=)



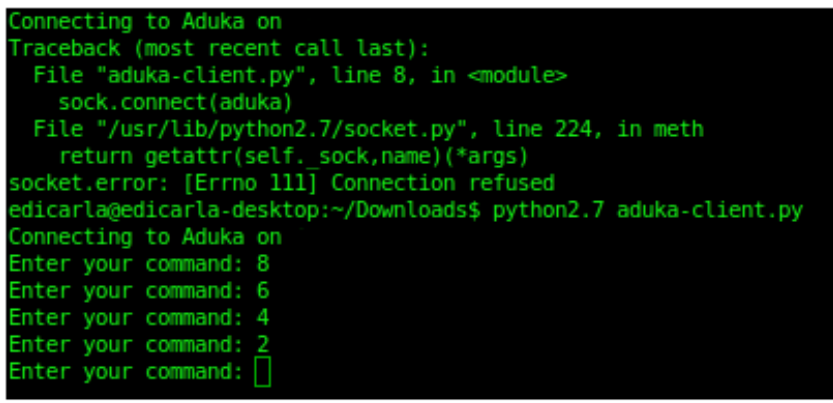
Master	Build	Queued	Built	Failed	Skipped	Ignored	Remaining
Ports - default							
10amd64-default	2015-09-27_03h59m46s	0	0	0	0	0	0
10i386-default	2015-09-27_11h59m12s	5	0	2	3	0	0
10armv6-default	2015-11-03_14h41m10s	71	46	5	20	0	0
11amd64-default	2015-12-18_11h13m15s	134	134	0	0	0	0
11i386-default	2015-12-19_01h10m07s	134	129	2	3	0	0
11armv6-default	2016-02-04_12h02m09s	56	50	2	3	1	0
10mips32-default	2016-03-22_11h18m24s	75	56	4	14	1	0
10mips64-default	2016-03-23_11h28m55s	139	0	1	138	0	0
11mips32-default	2016-03-23_13h40m55s	79	60	4	14	1	0
11mips64-default	2016-03-25_11h46m30s	80	60	5	14	1	0

Supervisory System for Aduka-I

- As soon as some packages were created and installed, an interface (Python) for controlling the robot just born.



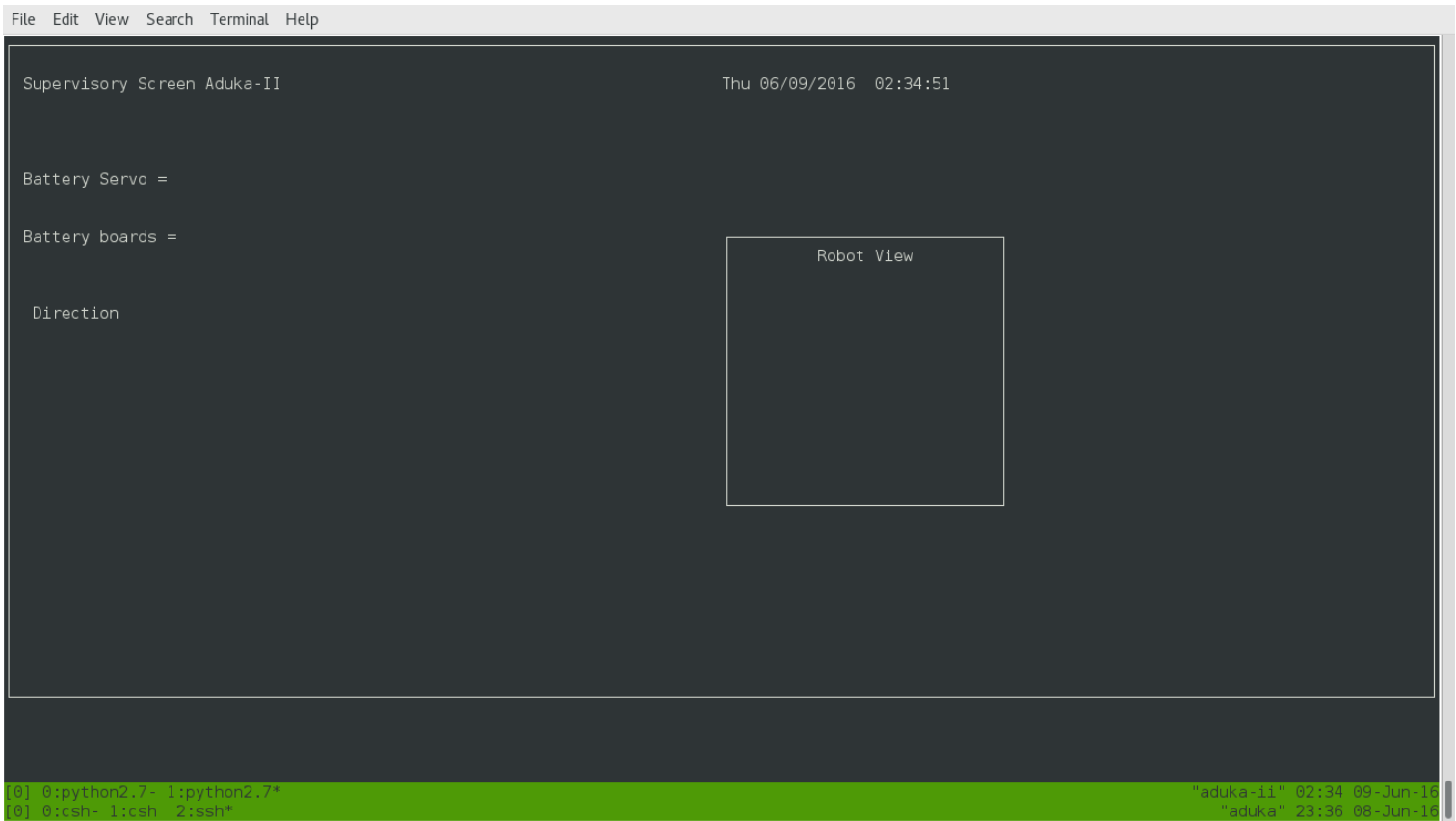
a) Servidor Aduka-I



b) Cliente

Supervisory System for Aduka-II

- The new version of the interface to control the robot.



Locomotion matrices

- Data was collected of line.

```
frente=[[610,1420,580,880,2460,1800,840,1520,2180,1100,2120,1700],
        [610,1420,580,880,2460,1800,640,1520,2380,1100,2320,1700],
        [810,1820,780,1280,2260,1400,640,1120,2380,1500,2320,2100],
        [610,1820,580,1280,2460,1400,840,1120,2180,1500,2120,2100],
        [610,1620,580,1080,2460,1600,840,1320,2380,1500,2120,1900],
        [610,1620,580,1080,2460,1600,660,1320,2360,1300,2300,1900]]

tras=[[810,1420,780,880,2260,1800,640,1520,2380,1100,2320,1700],
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      [610,1820,580,1280,2460,1400,640,1120,2380,1500,2320,2100],
      [810,1620,780,1080,2260,1600,640,1320,2380,1300,2320,2100],
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esquerda=[[810,1820,780,1280,2260,1800,660,1320,2360,1300,2300,1900],
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direita=[[810,1420,780,880,2260,1400,660,1320,2360,1300,2300,1900],
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         [610,1620,580,1080,2460,1600,640,1320,2380,1300,2320,1900]]
```

Flatenned Device Tree - FDT

Benefits:

- Put outside the kernel the device definitions;
- Same kernel for multiple similar boards;
- Make it easier to enable/disable devices after a kernel build;
- To mux the pins for alternatives functions;
- To list all the devices and their properties.

To enable or redefine some I/O pins just edit the .dts clear text file and compile the .dts into a .dtb binary file with dtc.

Demo

No live demo this time. It is too dangerous! Safety first]=)

What is next?

- Setting up magnetometer via i2c (position feedback);
- To include a camera for visual feedback (driver?);
- GPS;
  - Automated (moon)walking
- Battery status (ADC library).

Thank you!

Questions?