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A NetBSD-based Radar

in a Rocket Launching Center

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Agenda

- Context
- Problem
- NetBSD for the win
- ST2223 Telemeasurements System - A NetBSD-based Radar

Introducing

- C/C++ Unix Guy
- Software Engineering at Chocolate Software Laboratories (Brasil)
- ~~Fail: machine-learning recommendation as a service~~
- Now
  - R&D services for software development projects
  - Training services: C/C++ development for Unix, Qt
- Universities: USP, PUC-SP. Companies: Schibsted ASA, Orbisat/Embraer.

Context

Aerospace Landscape in Brasil

Alcântara Launching Center

Context

Aerospace Landscape in Brasil - Quick history

- 1961 - Government starts Brazilian space program
  - Military control
- 1994 - Government creates Brazilian Space Agency
  - Civilian control
- Focus on development of local space-related technology
  - Vehicles launching
  - Launch sites
  - Satellite manufacturing

Context

Aerospace Landscape in Brasil - Globally

- Rocket launching technology raise issues
  - Can be applied for civilian (space) and military (artillery) purposes
- INPE (National Space Research Institute) and NASA
  - Exchange data and expertise in civilian-related applications
- US and Brasil were once best friends (cold war)
  - Now closest relations are with China, Ukraine and Russia
- AEB (Brazilian Space Agency) 2013 budget: US$ 275 million
- NASA 2012 budget: US$ 17.8 billion

Context

Aerospace Landscape in Brasil - Infrastructure in summary

- Launching sites
  - **Alcantara Launch Center - CLA**
  - Barreira do Inferno Launch Center - CLBI
- Launching vehicles
  - VLS - Satellite Launch Vehicle
  - Variety of sounding rockets
  - Others in development (VLM - Microsatellite Launch Vehicle)
- Satellites
  - Several, many developed with China

Context

Alcântara Launching Center - Mission

CLA mission: launching of scientific and technological rockets.

- Strategic features
- Infrastructure

Context

Alcântara Launching Center - Strategic features

- Low population density
- Good (above average) security conditions
- Closeness to the Equator line
  - The closest launching base to the Equator
  - Up to 30% less fuel
- Near the sea (enable launching of huge rockets)
- Easy access by sea, land and air

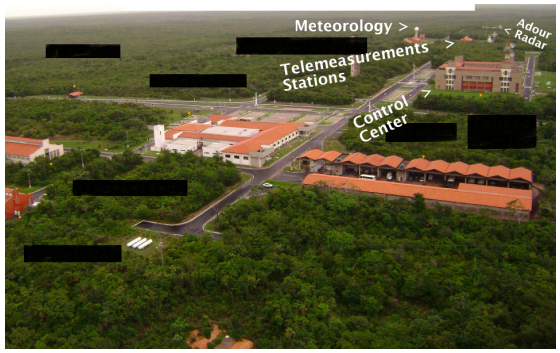
Context

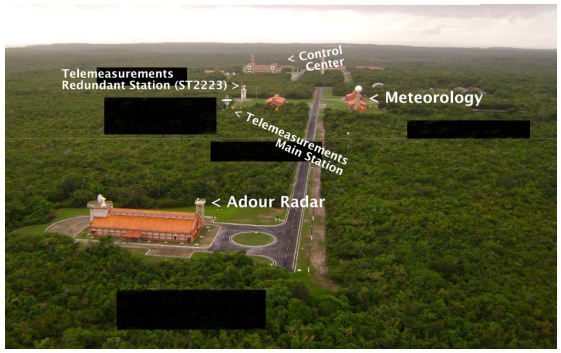
Alcântara Launching Center - Infrastructure

- Facilities
  - Propellants preparation
  - Payload preparation (scientific-technological experiments or satellites)
- Universal launch tower
- Mobile integration tower
- Control center
- Meteorological radars and facilities
- Telemeasurements & Tracking radars

Context

Alcântara Launching Center - Control Base & Raposa Site





source: Brasil's Ministry of Defence

Context

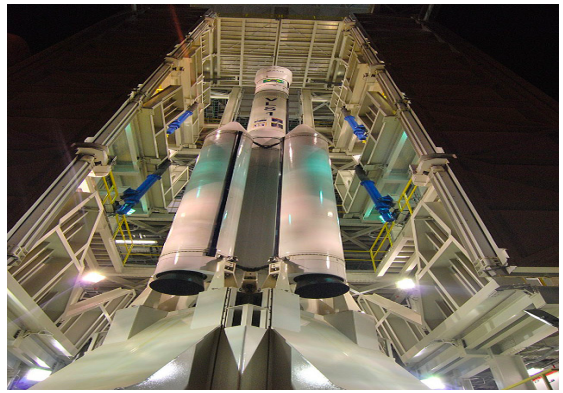
Alcântara Launching Center - Control Center



source: www.defesanet.com.br

Context

Alcântara Launching Center - Launchpad & Vehicles



source: www.defesanet.com.br

Context

Alcântara Launching Center - Radars

- Tracking Radars
  - Atlas-Thomson Radar (FR) - Precision sensor (azimuth/elevation)
  - Adour-Thomson Radar (FR) - Approach sensor (distance)
- Telemeasurements Stations
  - Thomson's Telemeasurements - Main station
  - **Omnisys' ST2223 - Redundant station (our NetBSD-based boy)**
- Telemeasurements what for?
  - Not for tracking purposes
  - Still needs to track target's signal automatically
  - Payload's data acquisition, transmission, recording and processing
  - More useful for launching or suborbital missions

Context

Alcântara Launching Center - Misc

- 30 years old (01/03/1983)
- First launch: December 1989
- 20 missions plus
- 457 rockets launched up to today (373 brazilian)
- 2012 base had 9 missions (a mark)
- BSD came just in time!

Context

Alcântara Launching Center - ST2223 Telemeasurements Station

source: www.omnisys.com.br

Agenda

- ~~Context~~
  - ~~Aerospace Landscape in Brasil~~
  - ~~Alcântara Launching Center~~
- **Problem**
- NetBSD for the win
- ST2223 Telemeasurements System - A NetBSD-based Radar

Problem

Software Engineering at Omnisys

Problem

Software Engineering at Omnisys - History & Projects

- Late 1997 - Omnisys Engineering founded
- Late 2005 - 1st programmer of Software Dev. Group (SDG) hired
- Early 2006 - Thales Group buy Omnisys
- Early 2006 - 1st intern hired
- Early 2007 - 6 people at SDG

- Thomson-Atlas (new radar display/control) - CLA
- Thomson-Adour (new radar display/control) - CLA
- ST2223 Telemeasurements Station - CLA
- Optical Tracking System - CLA

Problem

Software Engineering at Omnisys - CLA special requirements

Launching centers are special customers

- Isolated by 3000 km distance
- Expensive operation to deploy

Delivery Process

- Extensive testing (simulation) at our site
- Extensive testing (simulation) at customer site
- Deploy when sure
- Real targets tests (put base in operation)
- Deploy is for real, almost no rollback (during an operation)

Problem

Software Engineering at Omnisys - Implications

Home QA

- Minimum failure
- Simulate everything
- Predictability
- Reproducibility
- Maximum Control

Problem

Software Engineering at Omnisys - Challenges

Projects

- Build ST2223
- Atlas/Adour new Displays
- Detail Optical Tracking System

Internally

- Build a "jack of all trades" team
- Aerospace-level QA
- Build processes and infrastructure

Agenda

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- ~~Problem~~
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NetBSD for the win

NetBSD for the win

Infrastructure & Development Support Tools

- Unix development workstations
- Server
  - Backup
  - Network Services
  - Development
- Surrounded by supporting tools
  - Oscilloscopes
  - Signal Generators
  - Electronic prototypes

NetBSD for the win

Workstations

- As any other BSD
  - C/C++ Developer friendly
    - bmake, lex/yacc, awk/sed
    - Cross-compiling toolchain
    - mount_nullfs(8) (!)
  - pkgsrc
    - gmake, vim, kdevelpop, lisp, tcl, python, perl
    - sqlite, postrgresql, num-py, gnu-R
  - Qt (almost fully compatible)
  - Qwt

NetBSD for the win

Development Server

- Classic services natively:
  - FTP, HTTP, SMTP, DNS, NFS
- Good storage stack
  - needed for huge simulation datasets
- pkgsrc
- Development
  - No much memory or CPU
  - More than /home
  - No jail(8)
  - Let's try chroot(8)

NetBSD for the win

Development Server - chroot(8) environments

SHELL

```
export mnt_prefix=/mnt
export dev_path=/dev/vnd0
export img_path=/omnisys/software/netbsd/netbsd-2.1/i386cd.iso
export mnt_path=$(mktemp -d ${mnt_prefix}/${0}-XXX)
export dst_path=/omnisys/machs/temp.zumbi.$(whoami)

vnconfig -v ${dev_path} ${img_path}
mount -t cd9660 ${dev_path}d ${mnt_path}

for fset in ./text.tgz \
  ./misc.tgz  \
  ./man.tgz  \
  ./kern-GENERIC.tgz \
  ./games.tgz \
  ./etc.tgz \
  ./comp.tgz \
  ./base.tgz; do
  progress -zf ${mnt_path}/i386/binary/sets/${fset} tar -C ${dst_path} -xpf - ;
done;
cd ${dst_path}/dev
./MAKEDEV all
... # trigger for our custom configuration and packages setup scripts
```

NetBSD for the win

Development Server - chroot(8) environments

- Simple
- Customizable
- Vagrant-like (??)

NetBSD for the win

Simulation

- Simulation Machine <- Ethernet -> Target System Machine
- Components
  - simulation-producer (NetBSD)
  - simulation-proxy (Linux or NetBSD)
  - simulation-dev (Linux or NetBSD)
- Stable
- Robust
- Low-latency

NetBSD for the win

Product Governance and Engineering Processes

- Learn by doing
- Horizontality

- BSDs opensource KDB Project Management
  - Working with hats
  - Communication
    - engsoft-releng@, engsoft-misc@, engsoft-doc@, engsoft-project_name@, engsoft-commits@
  - Product Roadmap

- BSDs opensource KDB Engineering Processes and Product Governance
  - CURRENT->RELEASE->STABLE Branch model

NetBSD for the win

QA

- "Broken Build Hall of Shame"
- Regress tests
- Thanks to you Guys!

NetBSD for the win

Team

Left to right: Raimundo Santos, Vini (our guest), Silas Silva, Flavio Copola, Rodrigo Schimidt, Fabiano Lopes (missing)

source: Personal archive

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- ~~Context~~
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- **ST2223 Telemeasurements System - A NetBSD-based Radar**

ST2223 Telemeasurements System

A NetBSD-based Radar

ST2223 Telemeasurements System

Mission

- Ensure communication between rocket payload and the launching base

Features

- S-Band
- Frequency: 2200 MHz and 2300 MHz
- 4.5m Antenna
- 4 operation modes:
  - Manual, Nominative (or designate), Positioning, Automatic
- No emission (depends on payload's transmitter)
- Fixed target antenna
- Local and Remote HMIs

ST2223 Telemeasurements System

Internals (as any closed loop system):

- Receiver (sensor)
- Servo (controller)
- Other interfaces: Clock source, DO control, etc.

How we fit NetBSD?

- HMIs
- "Data-Switch"

ST2223 Telemeasurements System

Data-Switch

- Could be a hard real-time - QNX
- For control reasons - shall be a BSD
- Shall you take agressively to latency
- Avoids kernel work - Ethernet or RS232 for I/O
- Modbus (libmodbus)
- NetBSD 2.1
- Proprietary Application
  - No buffers, no queues, no priorization
  - Combine data with Universal clock source
  - Data exchange with other systems of the Base

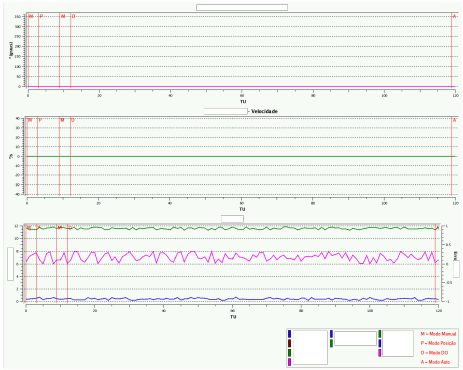
ST2223 Telemeasurements System

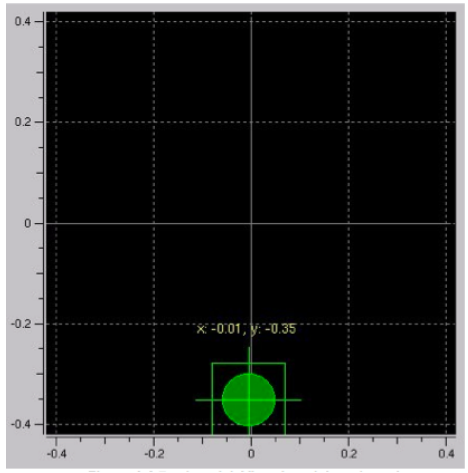
HMI

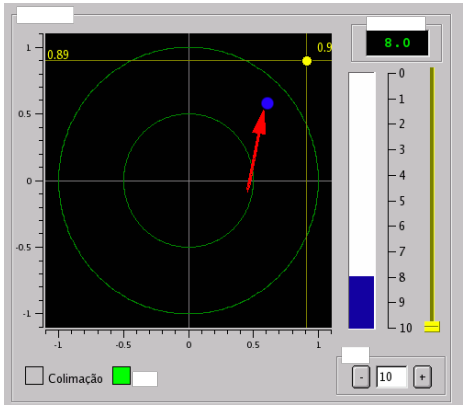
- SCADA
- Backend
  - C code
  - I/O
  - Data Demux
  - Data Recording (new process)
- Interface Frontend/Backend - publish/subscribe
- Frontend - GUI
  - C++, Qt, Qwt
  - Widgets

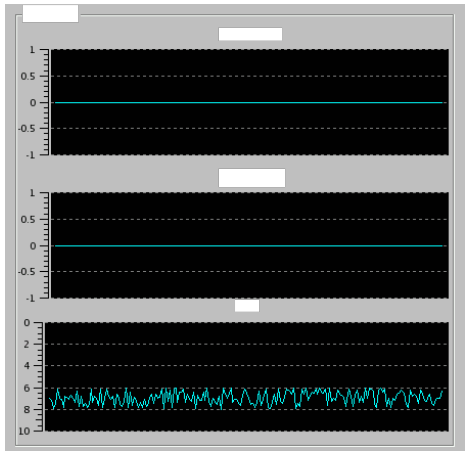
ST2223 Telemeasurements System

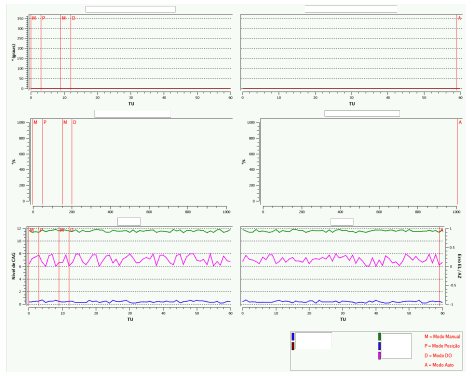
HMI - Widgets











ST2223 Telemeasurements System

NetBSD

- NetBSD 2.1
- Custom install
- Custom build on top of build.sh
- kqueue(2)

ST2223 Telemeasurements System

Patching NetBSD build

MAKE

```
# Makefile
build:
    chroot ${CHROOT} /usr/src/build.sh -U -u -x tools kernel=GENERIC build release
...
installbin:
    mkdir -p ${CHROOT}/usr/src/releasedir/i386/omnisys/pkg
    cp ${DESTDIR}/${QT} ${CHROOT}/usr/src/releasedir/i386/omnisys/${QT}
    cp ${DESTDIR}/${QWT} ${CHROOT}/usr/src/releasedir/i386/omnisys/${QWT}
    cp ${LOCAL_IHMTELM} ${CHROOT}/usr/src/releasedir/i386/omnisys/local-ihmtelm.tgz
    cp ${REMOTE_IHMTELM} ${CHROOT}/usr/src/releasedir/i386/omnisys/remote-ihmtelm.tgz
...
make-iso-image:
    TOOLDIR=/usr/src/tooldir.NetBSD-3.1-i386 DESTDIR=/usr/src/destdir.i38 RELEASEDIR=/usr/src/releasedir \
    chroot ${CHROOT} /bin/sh <<EOF
      cd /usr/src/etc;
      make iso-image;
    EOF
```

ST2223 Telemeasurements System

Patching NetBSD build

MAKE

```
# patch to list.change
list.patch:
  cat >> ${CHROOT}/usr/src/distrib/i386/floppies/ramdisk-big/$@ <<EOF
  # omnisys installer
  COPY  ${NETBSDSRCDIR}/distrib/utils/omnisys/omni-inst.sh omni-inst.sh 555
EOF
...
# patch to dotprofile
dotprofile.patch:
  ed ${CHROOT}/usr/src/distrib/i386/floppies/common/dot.profile <<EOF
/               sysinst
d
-
a
                # sysinst
                /omni-inst.sh
.
wq
EOF
```

ST2223 Telemeasurements System

Patching NetBSD build

SHELL

```
# omni-inst.sh essence
main() {
    disk_part wd0
    slice_part
    format_slices
    mount_partitions
    untar_sets
    boot_stuff
    # devices, fstab, rc_conf, x11
    final_config
    net_config
    app_install
    create_users
    umount_filesystems
    message "x - reiniciando";
    exec reboot
}
```

ST2223 Telemeasurements System

Final Words

- Atlas/Adour Display
- Optical Tracking System
- BSD in aerospace
  - Coherence, Self-contained, Easy to modify
  - Just fast!
  - Open KDB
    - Architecture references
    - Design patterns (Unix the only true repository)
    - Implementation reference
    - Project Management, Product Governance, Engineering Processes

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Questions?

Thank you!

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