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LOW-COST PLATFORM FOR THE PROCESSING AND CONTROL OF SENSORS THAT MAKE UP THE PAYLOAD IN REMOTE SENSING EQUIPMENT

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Abstract

In the development of equipment to be used in the remote sensing environment, it is recommended to consider in the design certain technical aspects such as: energy consumption, device size, performance, computational capacity, connectivity, radiation tolerance, among others. Therefore, certain electronic components capable of providing these characteristics are used, which makes their cost high and it becomes difficult to acquire these electronic components for special use. The proposal presented in this investigation, is the use of the embedded card Tegra TK1 of the NVIDIA brand, to be used as a base device for remote sensing equipment. This card provides considerable computational capacity. This card is composed of a CPU and the GPU, as well as communication buses and the communication card expansion to connect certain devices such as sensors and actuators. Another feature is fault tolerance and critical execution times that are critical in these types of equipment, among the main tasks, are the sending of telemetry, control of navigation devices, and synchronization among other tasks that will depend on the payload of the equipment. As a result, it is proposed to install a real-time operating system on the TK1 card, which ensures that the tasks are fulfilled in the established times and with the criticality that is required.

Keywords: Operating System, Real Time, Driver, Programming, Function, Task.

I. Introduction

Remote sensing equipment is characterized by the payload on board. These are accompanied by the limitations of the power supply, the size and its short life. These small teams are known as special drones Cubesat, Nanosat. [V] [VII]. Our proposal helps to develop these small teams, which allow to have all the computational capacity provided by the card. Designed primarily for the development of Artificial Intelligence applications, image processing, control processes. So you can use this computational capacity and configure to carry out the necessary tasks to be used as a control platform, known as the Central Control Unit. That is responsible for controlling the navigation devices, power, data transmission, telecommands, thermal control, control the sensors and all the devices that make up the payload. It is the essence of remote sensing equipment and depends on the payload it carries on board. Being able to use this card makes it possible to increase the capacity of the payload. By being able to insert a greater number of sensors and instruments (cameras) through its RS232 and I2C protocols, we can also have storage because it provides storage on SATA and SD hard drives. To be able to process images and data on board, it can be carried out due to its computational capacity based on its GPU. Where the whole process is carried out on board and the results are sent to the earth station.

All these features are backed by its energy consumption. The ability to integrate into a single card with increases the life of the equipment. Among the devices with similar characteristics We can find in the market many models and brands, among the best known we can mention the Raspberry pi, in its various models. These cards are commonly used in small projects but it is limited by their low capacity to connect sensors and storage devices, we can mention the arduino cards. These allow sensors to be installed for common tasks but it is limited for complex processes. The NVIDIA card has a fundamental feature of providing high connectivity and processing capacity in a single device.

II. Materials and Methods

Remote sensing equipment, located in space orbiting the earth, is known as satellite missions depending on its purpose and purpose. Fulfilling a specific task that is characterized by the payload, among the classic uses of remote sensing missions we can to mention:

- Earth Observation
- Navigation
- Telecommunication
- Science e investigación

In the design of the operation of remote sensing missions, leaving aside the payload, are those responsible for the operation of the satellite itself. Among the processes and tasks to be controlled we can mention:

- Central Computers & avionics communication networks
- Platform & payload Data-Handling
- Partially applicable to instruments
- Equipment processing & on-board software

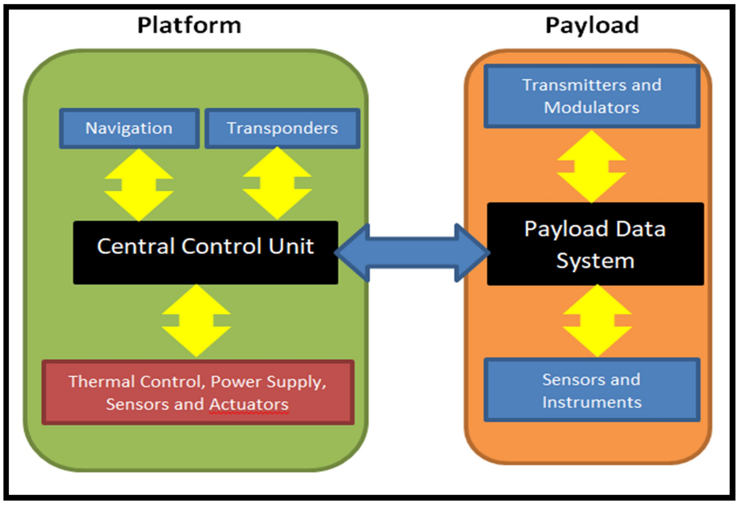

Fig. 1: Architecture of remote sensing equipment.

Useful Load

When we talk about payload we refer to the main function that remote sensing equipment will perform in space. This function depends on the instruments that are on board. Considering its capacity and resolution, grouping into two large families.

- Observation and sciencemissions:
    - Imageprocessing (compression y storage)
    - Scientificinstruments data processing
    - Higherdiversity of processingrequirements
- Telecommunicationsmissions:
    - Switching, Modulation/Demodulation
    - Veryhigh data throughput and processingrequirements
    - Performance

OperatingSystems in Satellites

Understanding as operating system, the set of programs that help the application programmer, manage the available hardware resources and that are critical. Like time and processor memory. When we talk about processor time, it is because it allows the application programmer to write programs as if each one was the only one using the CPU. The operating system is responsible for assigning the execution time to all programs and they are known as tasks. [VII].

Operating systems, in remote sensing equipment, are used to provide real-time applications, which process data entering the system, usually without delays. Among the most used are real-time operating systems. That is a "limited time system. It is characterized by having defined the execution time, so the procedure must be executed in the established times. In its structure it contains advanced algorithms to organize the tasks.

Operating systems, for remote sensing missions, run with a wide variety of tasks at the same time. One of its main features is scalability because at the time of execution they can be added with high priority, without causing any difficulty or returning an error. This allows a greater degree of code reuse, because if they are designed well, with little dependence, they can be incorporated into other applications.

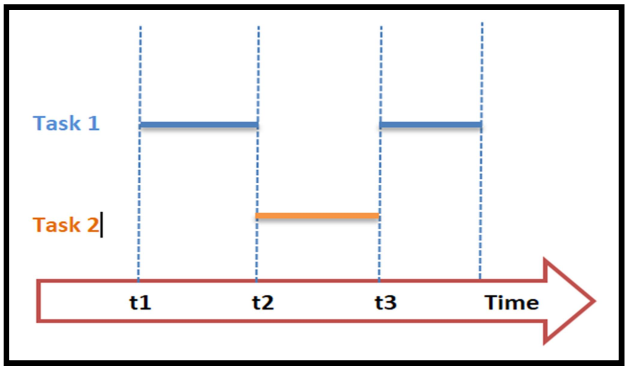

Fig. 2: Mode of execution of tasks in real-time operating systems.

Among the different operating systems in real time we can mention:

RTOS is a real-time operating system, with an emphasis on providing tools for application programs to meet temporary commitments defined by the programmer. It is used when you have to manage several tasks simultaneously with strict time periods. It also offers functionality to ensure that once an event has occurred, your response occurs within a limited time with strong handling of timers and waiting times, making the programmer practical in time management.

RTLINUX, this real-time operating system is characterized by its strong component in kernel design. The Linux kernel separates hardware from user level tasks. The kernel uses programming algorithms and assigns priority to each task to provide good performance or average performance. Therefore, the kernel has the ability to suspend any user level task, once that task has exceeded the time interval allocated by the CPU [I].

The user can achieve the correct synchronization of the processes by deciding the programming algorithms, the priorities, the frequency of execution, etc. The RTLinux kernel assigns the lowest priority to the standard Linux kernel. Thus, the user task will be executed in real time. RTLinux coexists with the Linux kernel, as it leaves the

Linux kernel intact. Through a set of relatively simple modifications, it manages to convert the existing Linux kernel into a difficult real-time environment without hampering the future development of Linux.

RTAI, commonly known as an interface for Real-Time Applications, is a real-time Linux implementation based on a principle in RTLinux, it is not an operating system itself. It is based on the Linux kernel, providing the ability to make it completely requisitionable. RTAI adds a small real-time Linux kernel under the standard Linux kernel and treats the Linux kernel as a lower priority task. RTAI also provides a wide selection of communication mechanisms between processes and other real-time services. It has an architecture similar to RTLinux treating the standard Linux kernel as a real-time task with the lowest priority. Which makes it possible to execute when there is no task with higher priority running. The basic operations of real-time tasks are implemented as kernel modules as well as RTLinux. [II].

ChibiOS / RT, is a real-time portable operating system designed for integrated applications that can run on embedded hardware, ChibiOS / RT can be useful for applying concepts on integrated operating systems and related topics such as cross compilation. Thread context change, concurrency control, interrupt processing and development of device drivers. The base code is much smaller than Linux and, therefore, much more accessible and easy to understand. One of the features that makes it particularly different is its portability so it can be run on multiple small platforms, providing a complete development environment for integrated applications that includes peripheral controllers, support files and a development environment. [III].

Control Systems in RemotesensingeQuipment

When we talk about control in the management of remote sensing systems, we mean having high functional capacity and accuracy in the processes taking into account the execution time. Among these features are the tasks performed by the on-board computer.

The basic functions of the control system is characterized by:

- Monitoring
- Event Management
- On-board Storage
- Memorymanagement
- Telecommand
- Telemetry

Amongthemostcriticalfunctionsthat can affectoperation are:

- On-boardoperationsprocedures
- On-boardoperationsScheduling

- Housekeeping

These functionalities vary depending on the complexity of the remote sensing equipment and the payload it has on board.

Proposal

The proposal is characterized in proposing the use of the Jetson TK1 card as a base platform to be used as a Central Control Unit (on-board computer) and as a payload control system, and as a central software for process control. RecommendsFreeRTOS as a real-time operating system.

Hardware Proposal

The TK1 jetson card is considered by NVIDIA designers as the first supercomputer for mobile systems. Designed for applications where it requires a high level of processing, such as image processing and real-time data processing. [VI].

As main features of the card, it is its 326 GFLOPS computing capacity that gives us its 192 CUDA cores and among its specifications we have:

- Dimensions: 5" x 5"
- Tegra K1 SOC (CPU+GPU+ISP in a single chip, withtypicalpowerconsumptionbetween 1 to 5 Watts)
- GPU: NVIDIA Kepler "GK20a" GPU with 192 SM3.2 CUDA cores (upto 326 GFLOPS)
- CPU: NVIDIA "4-Plus-1" 2.32GHz ARM quad-coreCortex-A15
- DRAM: 2GB DDR3L 933MHz EMC x16 using 64-bit data width
- Storage: 16GB fasteMMC 4.51
- Mini-PCIe, SSD RAID, FireWireor Ethernet
- SD/MMC card: a full-size slot
- USB 3.0: a full-sizeType-A female
- HDMI: a full-sizeport
- RS232: a full-size DB9 serial port (routedto UART4)
- Audio: an ALC5639 Realtek HD Audio codecwith
- Ethernet: a RTL8111GS Realtek 10/100/1000Base-T
- SATA: a full-sizeportthatsupports 2.5" and 3.5" disks, butisnothot-pluggable. (Turn off thepowerbeforeplugging in SATA disk drives)
- JTAG: a 2x10-pin 0.1" portforprofessionaldebugging
- Power: a 12V DC barrelpowerjack and a 4-pin PC IDE powerconnector, using AS3722 PMIC

- Cuenta con un puerto de expansion donde encontramos los siguientes puertos: Camera ports: UART, HSIC, I2C, GPIO.

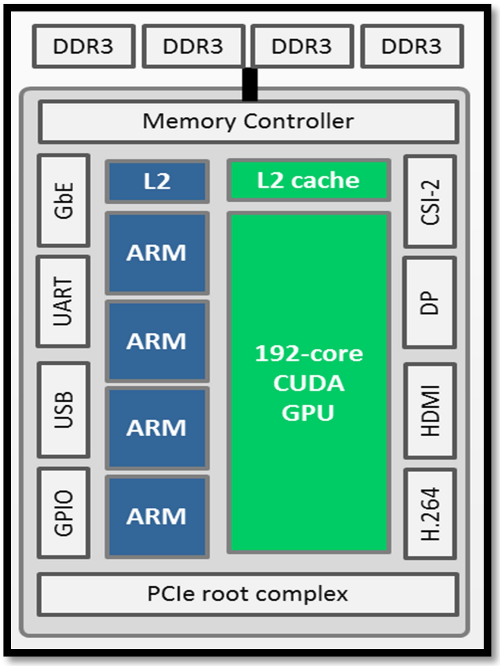

Fig. 3: Block diagram of the jetson TK1 card.

Software Proposal

Embedded systems are platforms with scarce resources when compared to resources that have a PC. Which is why they do not normally have a complete operating system.Which is why in most operating systems they only have subsets of functions that can handle it advantageously and only run at certain times that the system requires.

FreeRTOS, is a real-time mini kernel that in many cases provides necessary and indispensable services, allowing compile only the functions they are going to use and that are necessary which causes a positive impact on the use of memory. Offering timing functions, communication between different tasks, synchronization between tasks and interruptions and in the definition of critical sections. [IV].

Among the advantages we can indicate:

• Free access and no implementationcost

• Practicalimplementation

• Implementations are mostlywritten in C

- Lightweight in codesize and in RAM usage

III. Results

Among the expected results we can mention that remote sensing equipment can be designed, it was possible to configure the Jetson TK1 card as an on-board computer. Having as a real-time control system the FreeRTOS. The configuration of the card as well as the operating system depends on the specifications of the payload, as well as the navigation and transmission mechanisms, the detail of the technical specifications was first made and then the card configuration was carried out.

In the installation of the operating system, we can indicate that the jetson TK1 card has Ubuntu 14.04 installed by default. Depending on the complexity of the design the kernel can be patched otherwise implement modules, this procedure will depend on the experience of the development team on issues of programming.

Among the features of the proposed software we can indicate:

- Systembasedonlanguage C.
- Kernelbasedon real time.
- Math and control libraries
- Proceduresforon-board control
- File manager system

In order to define the characteristics, the functionalities to be developed by the team are indicated:

- Verification of telecommands
- Housekeeping
- EventReport
- Administrationfunctions
- Parametermonitoring
- Onboardstorage
- Testingservice
- Eventmonitoring

The mechanism so that these functionalities can be executed depending on the complexity of the control of the equipment. A function in FreeRTOS was designed for each one of the described functionalities, in this way whenever it is required, the function will be called to be able to be executed.

IV. Conclusions

In the experience of developing electronic devices and control software. We always think that these devices will work in the best conditions on land. When we refer to systems that will work in space, these conditions change dramatically due to the interaction of certain phenomena that occur in space, one of the main ones is the interaction with the sun, through solar radiation and these are different with respect to the land, due to its proximity to the proposal. It is based on being able to have a real-time base control system, to carry out the field tests it is suggested to consider the following considerations in the design of the compartment trying to take care of the components found in its interior.

- Performheattreatmenttoisolatethesystem.
- Considermechanismsforradiationtolerance.
- Considermechanismstoworkundertheeffects of severityvariability

Due to the size and weight, a redundant system can be considered in the design that helps to have small satellites with longer life. The proposal can be improved by considering the recommendations based on the technical standards of the ECSS (European Cooperation for Space Standardization). Such as printed circuit procedures, verification, quality assurance, electrical interface, software, among others.

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