QuickSAT: An Environment for Space Exploration

A Space Hypervisor, Radio, Vehicle Management System and Satellite Design Tool

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ENVIRONMENT: **STEP_SATDB**

- QuickSAT™
- NASA Applications
- CAD Tools
- SINDA
- NASTRAN
- STK™
- SOAP™
- Mathematica™
- MatLab™
- Other Apps
- step_SATdb™
- XML and SQL Interface

Create Custom Views and Taxonomies

sci_Zone, Inc.
www.quick-sat.com
QuickSAT/Xen
Space Hypervisor
Motivation

- Federated vs. Integrated
  As microprocessors become more powerful, previously independent systems are now integrated on to one computing platform.

- Isolated vs. Connected
  In the past, embedded devices were generally isolated from broader networks. Today, embedded devices are increasingly interconnected.
The Problem

Need a **Safe AND Secure** embedded platform solution, without compromising **Performance**…

Security concerns in safety-critical systems are now paramount; and Aerospace & Defense, Medical, and Automotive markets are all demanding a solution.

…**QuickSAT/Xen** open-architecture hypervisor with unrestricted licensing of **Xen** provides **safety**, **security**, and **performance** on an embedded platform.
The Solution

Unrestricted ARINC 653 Xen-based Hypervisor

- Unrestricted via open source licensing
  - Software source code is openly available (not proprietary)
  - Industry and military are pushing for non-proprietary solutions
  - Community development leads to higher reliability, modern OS features, state-of-the-art tools

- ARINC 653 Open architecture/standard
  - Partitioned operating environment provides safety via isolation of software applications
  - API standardization leads to commonality of approach, better re-use, lower certification cost
  - Adopted and driven by the avionics FACE consortium

- Xen Hypervisor
  - Multiple computing hardware platforms (PC and embedded)
  - Multicore processor performance support
  - Multiple apps on one processor, isolated for safety + security
Benefits

- Security
  - Multiple Independent Levels of Security (MILS EAL6+) by Formal methods mathematical proof of correctness
  - Isolates software into their own partitions, regulates information transfer
- Safety
  - DO-178B Certification with Design Assurance Level A
  - Certification artifacts
- Performance
  - Low overhead virtualization
  - Low latency via ARINC 653 I/O interrupt
  - Multicore
Sustain Legacy Systems by Migrating Functionality to the Hypervisor
The Xen Hypervisor Environment

DOM0 Controls the Hypervisor Environment

QuickSAT began development in 2006 of this innovative Satellite Design Automation and manufacturing architecture – a collaborative, "push button" design and manufacturing environment and methodology.

Xen Hypervisor Profile

Linux Profile

- Task
  - ARINC 653 I/O Mgr.
  - PV Network Driver
  - PV Block Driver

Android

- Task
  - ARINC653 API
  - PV Network Driver
  - PV Block Driver

VxWorks

- Task
  - ARINC653 API
  - PV Network Driver
  - PV Block Driver

Integrity

- Task
  - ARINC653 API
  - PV Network Driver
  - PV Block Driver

Unprivileged Domains

Domain 1

- Android

Domain 2

- VxWorks

Domain 3

- Integrity

Legend

- Certified Components
- Client OS
- Phase 1: Core Functionality of TOE
- Phase 2: Core Functionality of TOE
- Phase 3: TOE

Multiple “Virtual Machines” securely linked via the ARINC 653 CPU Scheduler

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HAL-M: The Software Rad Hardening Manager

QuickSAT/step_SATdb

Flight Plan
Modes of Operation
Configuration Models/
Payloads/Parts

QuickSAT/Scheduler

QuickSAT/VMS

HAL-M Software Rad Hardening Manager

Control Domain
(dom0)

MCP
PV Back Ends
HW Drivers

Xen Hypervisor with ARINC653 Extensions

Payloads Comm Memory CPUs

Guest VMn

Apps/
Payload Software
PV Front Ends

Guest OS

Flight Hardware or
Simulator

External Modeling,
Simulation Tools

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QuickSAT/Vehicle Management System (VMS)

Your window into your satellite
EyeStar Radio & QuickSAT

EyeStar: A Paradigm Shift
Small Satellite Comm Issues

- Difficult to find
- Difficult to acquire
- Limited ground communications

Enter EyeStar...
EyeStar Quality CubeSat Comm Link
“the Edge of Exploration”

- Professional demanding missions
- Reliable and seamless data link
- Many comm. systems associated with CubeSat failures and require significant flight hardware and tracking time/cost
- Complements high-data rate downlinks Beacon GPS, Health, Back-up and Sample data sets
- EyeStar Unified Constellation Data Base
• GlobalStar Constellation
  • 32 LEO Satellites (1400 km)
  • Provides global data and voice services for ~ 300,000 customers
• Used primarily for infrastructure/wildlife monitoring
  • Oil Rigs
  • Shipping Containers
  • Gas pipe-lines
  • Endangered animals
• EyeStar developed by NSL for high altitude ballooning
  • Data links via the GlobalStar network
    • Payload commanding
    • Data downlinks
    • Recovery tracking (with GPS)
EyeStar Product Features

• Ground station over Internet Protocol (IP)
  • Access your spacecraft from anywhere
  • Piggy-backs on established 2 billion dollar network

• Low Cost
  • No Ground Station
  • No tracking
  • Proven system
EyeStar Features

- Small form factor
  - Power
    - 200 mW Tx power
  - Volume
    - 44 mm x 81 mm
  - Electrical
    - Accepts 5 V to 20 V
    - TTL Data Protocol
EyeStar Product Features

• No deployables
  • 2 cm x 2 cm patch for simplex
  • 2.5 cm diameter circular patch for duplex
• Rapid acquisition
  • Received the first TSAT beacons 11 seconds after turning on
• Not ITAR Restricted
• High data rates limited
  • 9600 kbps maximum (advertised)
  • GEARRS & SHARC will investigate maximum data rate
  • EyeStar intended to compliment traditional high speed radios
EyeStar Product Features

- Anytime, Anywhere Satellite TT&C
- 50% of the packets transmitted by TSAT were received
- Estimated 98% orbital coverage for ADCS Controlled S/C
  - Common FCC Satellite-to-Satellite License
- Delivered with the EyeStar Radio
- No Amateur bands
- Radio astronomy interference was eliminated by limiting the GlobalStar units to operate at 1616.25 MHz with a bandwidth of +/- 1.25 MHz
- No satellite to ground license required
EyeStar Simulations
(“Bent Pipe” distributed data downlink)
Road Map To Flight Certification

- TSAT
- GEARRS
- SHARC
TSAT

- Taylor University 2U Spacecraft
  - Demonstrating the EyeStar Radio
  - Beacons only, no commanding
  - Started in 2012 as a capstone project

- TSAT was launched on 4/18/14
  - SpaceX CRS-3
  - NASA ElaNa 5
  - Built by Taylor University and Near Space Launch
I I Sec after Radio Turned On
Plasma Density
Preliminary TSAT Coverage Map

Beacon Cycle
- 32 beacons
  - One every 5 seconds
- 15 minute dwell
- 5000 packets received

45% packet throughput on a tumbling satellite

Near Global Data Downlink Coverage
Plasma Temperature
GlobalStar releases cap on packet distribution rate
GEARRS

- GlobalStar Experiment and Risk Reduction Satellite
  - Collaboration between NSL and AFRL
  - 94 day CubeSat
    - Kickoff: December 17th
    - Delivery to NanoRacks: March 21st
  - Launching on Orb-2
    - June 6th
    - Soft-stowed with cargo
  - Deployment from ISS
  - Testing full EyeStar product
    - Duplex and Simplex
    - Higher data rates
SHARC

- Testing full Duplex Mode of EyeStar
- Testing the FRNCS-P Flight Computer, a multicore ARM-15 based computer
- Testing the QuickSAT/Xen Hypervisor
- Space Certification QuickSAT/VMS
EyeStar Path Forward

- sci_Zone
  - CubeSat Developer Interface
  - Vehicle Interface
  - Data Servers
  - Data Security
  - Quick-Sat.com
  - Single POC with GlobalStar
  - Relationship with GlobalStar still in the early stages
  - Hardware - The Radio
  - Design
  - Distribution
  - FCC Licensing
  - Legal
QuickSAT
Take your satellite from idea to flight!

QuickSAT/Designer
Design and Mission Planning from idea to flight!

QuickSAT/Xen
Security, Reliability and Software Rad-Hardening!

QuickSAT/VMS
Talk to your satellite!

FRNCS
ARM Computing for the Future!

sci_Zone, Inc.
www.quick-sat.com
Next STEP - Join the Fun!

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