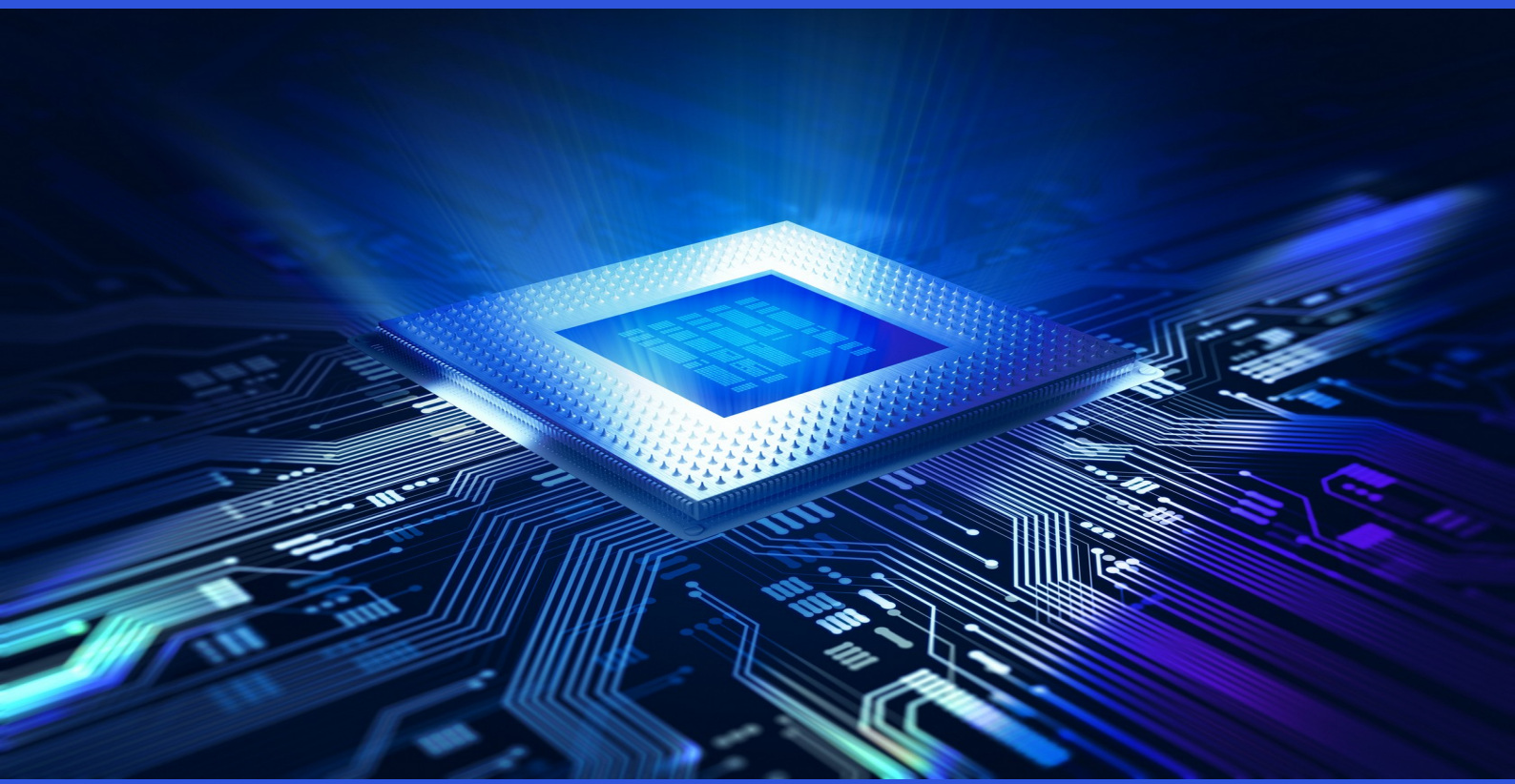
Network Software Stack AimOS Robo

White Paper



AimValley

AimValley

AimOS Robo
White Paper

Table of Contents

AimValley

AimOS Robo
White Paper

1. AimOS Robo Introduction

AimOS is a collection of software assets and tools to develop carrier grade telecom and datacom systems. It is a field proven solution with a first deployment in 2003 and has been used in more than 100 000 shipped systems. Several versions of AimOS exist. AimOS Robo is a version based on Broadcom's® RoboOS and it supports the Robo Ethernet switch family.

The RoboOS is a modern network stack targeted for web managed switches developed by Broadcom®. RoboOS is built using a combination of Broadcom® proprietary, open source (Non-GPL) and third-party code. RoboOS utilizes the internal embedded processor and memory within the Robo2 series. This results in a portable network stack within the Robo switch family, only dependent on the supported flash types.
The Broadcom® RoboOS software is intended as an example or evaluation package for customers to use and with which to build their own switch management solutions.

AimValley has hardened and integrated RoboOS into AimOS resulting in a new version called AimOS Robo. Hardening was done by adding features such as file system robustness and persistent logging. As a result AimOS Robo can be used as a field grade switch management application for the Broadcom® Robo2 series switches without the need for an external CPU.

2. AimOS Product Family

The AimOS Robo is targeted for the embedded CPU in the Robo2 switch family. As the embedded CPU is limited in resources the feature set of AimOS Robo is also limited when compared to the AimOS Ethernet version. If more features are required an external CPU running the AimOS Ethernet software version is a good alternative.

3. Robustness features

The AimOS Robo includes the following hardening enhancements:

- **File System Robustness**
  Makes the system fully resilient against power failures with very little run-time overhead.
- **Persistent logging**
  Adds functionality for storing all debug information of the system to a circular log on the system's flash chip and for retrieving the contents of the log through the systems web interface.

3.1 File System Robustness

RoboOS uses configuration files to save settings across reboots. Those configuration files are stored in Flash memory, on a dedicated area (with a default size of 1 MiB) which contains a FAT12 file system. Unfortunately, the FAT file system layout does not provide any protection against unexpected system shut-down. In particular, if an untimely power failure interrupts a write operation to the file system, then the file system itself can be left in an internally inconsistent state. AimValley has added robustness features to the RoboOS to prevent corruption of the file system and loss of configuration data in the presence of power failures.

AimValley
Utrechtseweg 38
1213 TV Hilversum
The Netherlands
phone +31 35 689 1900
sales@aimvalley.com
www.aimvalley.com

The key features are:

- **File system consistency**
  The file system robustness feature guarantees that if the file system was in a consistent state before a power failure, it is recovered to a consistent state after the subsequent boot as well with no loss of data that had already been committed to the file system before the power failure. Further improvements prevent loss of free space on the file system or inconsistencies in the file system.
- **Application-level consistency**
  If a power failure occurs while a configuration file is being updated from old to new contents, then after the subsequent system boot, readers of that configuration file will find either the old or the new contents of the configuration file. They will never find a missing configuration file, an empty file, only partial contents, a mix of the old and the new contents, or anything else.
- **Efficiency**
  The robustness feature introduces only limited performance overhead. Updating a configuration file at run time and system recovery is not noticeable slower than it was before.

- The file system robustness has been rigorously tested and proven to work; **more than 20 000 cycles** of power loss during file system writes were **tested**.
- In 12% of the recoveries the additional hardening feature of AimValley prevented file system corruption, resulting in **100% error free recoveries.**

3.2 Persistent logging

The Broadcom® RoboOS writes all the debugging output of the system only to the serial link. The AimOS Robo hardened version provides persistent logging. In particular, the persistent logging feature allows later retrieval of output that may be critical for debugging problems in the field. One important example would be a crash of the operating system. Without the details of the run-time exception that occurred, it would be virtually impossible to figure out what happened. The persistent logging feature ensures that such information is available long after the crash. However, rather than just capturing the most important crash information, also other debug output of RoboOS is captured to ensure that the log contains all possible information that may help with debugging issues.

3.3 Other improvements

Compared to the standard RoboOS several other improvements have been added to AimOS Robo. For example;

- added internal inconsistency checks and guaranteed continuous booting while system integrity is in proper condition,
- web GUI performance has been improved and is now up to 3 times faster,
- the auto-negotiation status of each port is now visible in the GUI,
- auto-negotiation can be configured for ports that allow this,
- factory-friendly provisioning of system information parameters such as MAC-address and LED-behavior.

4. Feature Overview

The table shows a summary of the features of the AimOS Robo and the standard Broadcom RoboOS version.

Feature Description	AimOS Robo	Broadcom® RoboOS
Web interface – GUI	✔	✔
File System Robustness	✔	✘
Configuration versioning	✔	✘
System Information	✔	✘
Software upgrade	✔	✔
Configuration up- and download	✔	✔
Persistent Logging	✔	✘
System Sanity	✔	✘
System Reset	✔	✘
Heartbeat Message	✔	✘
Ethernet forwarding	✔	✔
VLAN handling	✔	✔
Traffic Classification	✔	✔
Port Rate limiting	✔	✔
RSTP	✔	✔
LLDP	✔	✔
LAG	✔	✔
IGMP snooping	✔	✔

4.1 Feature details

Following overview describes features that are exclusive to AimOS Robo.

File System Robustness

An addition to the flash- and file system handling to make the system resilient to power outages/crashes which would otherwise corrupt the file system. Adds file system consistency and adds application level consistency.

Configuration Versioning

Versioning is added to the configuration database. This allows the application to recognize whether a database is compatible with the running software. If the database is incompatible measures can be taken to prevent erratic behavior of the system. Current approach is to remove an incompatible database.
Future implementations may offer database migration.

System Information

An area on the flash is reserved to store production parameters. Examples:

- Serial number
- MAC address
- Production date

The area is protected by a checksum and can be extended. Currently used to store the MAC address as well as storage of the board type, which is used to select a LED configuration.

Persistent Logging

Logging of application debug messages to flash. Unused sectors are allocated for logging. Logging takes place in a round-robin method so that flash wear is evenly spread over the sectors. The log file can be retrieved via the web interface or, when required, extracted from the Flash chip directly.

System Sanity

Provides status/health information of the system and is retrievable via the web interface.

- Boot status OK/alternate image booted/watchdog.
- TOC: OK/repaired.

System Reset

A reset operation was added to the web interface under the maintenance section.

Heartbeat Message

Message, sent with a provisionable rate, to a provisionable IP address and UDP port.
Example message contents (customizable on request):

- System Sanity data
- Port link status
- Port error status
- Key PM counters

Utrechtseweg 38
1213 TV Hilversum
The Netherlands

phone +31 35 689 1900
sales@aimvalley.com
www.aimvalley.com

Traffic Classification

Per port configuration of classification characteristics. Adds flexibility to application of global classification rules.
Per port selection of:

- Default traffic class
- 802.1p classification
- IP DSCP classification

Robustness

A large number of updates has been made to improve robustness and to fix issues in the following areas:

- Boot sequence
- Configuration processing
- Flash handling
- Multi threading
- Memory management
- Protocol implementation
- Data representation

5. Licenses

For binary distribution of the AimOS Robo, including the Broadcom® driver, the Mongoose web server and the FreeRTOS, it is sufficient to sign a license agreement with AimValley.
Contact AimValley sales (sales@aimvalley.com) for details about source distributions. For every distribution AimValley can provide a Free and Open Source Software (FOSS) report.

6. Hardware requirements

The AimOS Robo runs from the internal Robo2 CPU and memory. The only external resource it depends on is the flash memory. RoboOS software supports only SPI flash devices and not QSPI. Most QSPI devices are backwards compatible with SPI.

The RoboOS flash driver can use flash devices from Cypress/Spansion, ST, Micron, Macronix and Winbond which support the following instructions:

PAGE_PROGRAM	0x02
WRDI	0x04
RDSR	0x05
WREN	0x06
FAST_READ	0x0B
RDID	0x9F
ERASE_SUBSECTOR	0x20
ERASE_CHIP	0xC7
ERASE_SECTOR	0xD8

The flash chip must support sub-sector erases for 4 KB on all areas of the flash. The software driver currently only supports 3 byte addressing (up to 16MiB Flash).

AimValley
Utrechtseweg 38
1213 TV Hilversum
The Netherlands
phone +31 35 689 1900
sales@aimvalley.com
www.aimvalley.com

AimValley

AimOS Robo
White Paper

AimValley Embedded Software Expertise

- Development of high-speed 100+ Ethernet interfaces applied in testing equipment.
- 100G Ethernet switch designs.
- Experience in applying high-speed FPGA transceivers.
- FPGA level high-speed frame processing.
- High-speed designs achieving the best possible signal integrity including analog simulation technology.
- Development of OTN transport and multiplex systems.
- Architecture and design of clocking and synchronization solutions at network, system, PCB or device level, incl. PLL and gearbox designs.
- Experience in creating time, frequency and delay critical solutions.
- Design and architecture of Ultra Low Latency solutions.
- Development of LIU front-end technology.

AimValley proven track record

- AimOS Robo Board
- AimOS Family
- AimOS Ethernet
- AimOS Development Kit R2

Why AimValley?

AimValley is a reliable provider of Embedded Software technology since 2003, delivering solutions for:

- High speed data processing applications
- Complex FPGA-based accelerated systems
- High speed, low power hardware equipment
- Robust embedded software
- Early adopter of Acceleration Technology

AimValley understands the full complexities as well as the subtle nuances of designing great edge solutions. We excel in building complex systems that are part of your product in the fields of Industry 4.0, Big Data, Healthcare and Transportation markets. Our combined skills represent all the important aspects required for the development of end-to-end systems.

Our customers enjoy the benefits of working with a strong team with over 2000 years engineering experience. AimValley is a trusted partner of Tier 1 customers in Telecom and Industrial markets and has shipped more than 100 000 products.

Quality Focus

- Outstanding track record of on-time delivery
- Best in Class Designs – Time, Budget & Quality
- ISO9001, ISO140001, EcoVadis Platinum CSR

Further information

Our experienced engineering team with expertise in systems engineering, software, hardware and FPGA design can support you with all steps in your product development. The Broadcom® experience of our teams is well known in the industry. For further information contact sales@aimvalley.com

Utrechtseweg 38
1213 TV Hilversum
The Netherlands

phone +31 35 689 1900
sales@aimvalley.com
www.aimvalley.com