Fast BIOS Case Study

Five9NS' Collaboration to Win Federal Bids

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This document summarizes the work performed to develop a fast BIOS for a mission critical application running on the Five9 Network Systems X2000 server. The document highlights Five9 Network Systems core competency of offering differentiated products and dedicated engineering support.

Executive Summary

The X2000 Server was designed and manufactured by Five9 Network Systems for a prominent Federal Systems Integrator in their quest to secure a major contract for a significant Federal Agency's mission critical application. Off-the-shelf technology available from IBM, Sun, HP and Dell met some Bid requirements. However, several key, special requirements were left unaddressed by commercially available computer servers. As such, the Federal Systems Integrator turned to Five9 Network Systems for a complete solution that in the long run made significant contributions, delivering the competitive differentiation needed to win the bid.

With a limited time-to-bid, Five9 Network Systems launched two parallel design programs; The Fast BIOS Project and a new Multi-Function I/O PCIe Option design project to eliminate two critical hurdles:

> The Federal Agency's mission critical application running on commercially available servers clocked in with a prohibitive 60 seconds BIOS boot time. The Five9NS Project delivered extreme differentiation with a Boot Time of 15 seconds.

> Work space in the Federal Agency's offices is of the utmost importance. With work space having top priority, any remaining space is sacrificed in accommodating server sprawl. By designing a multifunction I/O interface for the application, all required network ports and audio output were made available, giving back precious space for the Federal Agency's work environment.

The X2000 met all of the design standards defined in collaboration with the Federal Systems Integrator. With a goal to exceed requirements, maximum competitive differentiation was achieved. The Federal Agency selected the Federal Systems Integrator, with Five9 Network Systems delivering thousands of X2000's per year to the delight of all involved.

This case study is offered as an in-depth look into Five9NS' capabilities critical to the success of the Federal and Commercial Systems Integrator community.

Introduction

The Five9 Network Systems X2000 is a specialized workstation / rack-mount server that is designed to meet stringent acoustic noise, thermal and footprint requirements and hence can operate in an office environment. This product provides a system level solution that was integrated by our customer to run a mission / life critical application where every second counts.

The Problem

Given the mission critical nature of this application, the customer required the optimization of the boot time to achieve an overall requirement of recovery from an AC power failure to full functionality of the program in 60 seconds. The system BIOS boot time had to be reduced from 60 to 15 seconds without detrimental effects to the OS functionality or to the application software. It also had to support all the program's I/O devices including the Five9NS Multi-Function I/O card, a serial interface card, 3 different graphics cards, multiple external USB devices and of course full functionality of the I/O ports in the system. This made the BIOS work even more challenging as a total of 13 different configurations using the cards and devices mentioned above had to be supported.

Work Plan & Implementation

Approach 1

The first strategy implemented for this project was to use a commercially available fast BIOS and add / remove functionalities to customize it to the customers' needs. This approach was mainly chosen to de-risk the project and allow for a faster deployment schedule.

An alpha drop was developed as a proof-of-concept and delivered to the customer to demo to the end user. Although the end user was happy with the demo, this approach was subsequently abandoned for 4 main reasons:

1- The best boot time that could be achieved was 22 seconds to GRUB

2- It did not provide the capability to NetBoot or boot to an EFI shell to perform maintenance tasks

3- Installing the BIOS involved opening the X2000 chassis and clearing CMOS by moving the corresponding jumper which is not a perfect solution for field retrofits

4- A loopback cable was required on the serial port during rapid boot

This approach also necessitated workarounds in the OS, like bypassing the BMC wait time after an AC power fail, manually resetting the FRB Watchdog via remote BMC to prevent a reboot after 6 minutes from power on. Another challenge was adding a timestamp to the source code to capture full BIOS completion. We had to use a stopwatch and wait until the GRUB menu is displayed on the screen to take a measurement which does not capture the accurate boot time.

This work however helped define a revised set of requirements for a fast boot BIOS including functionality, feature support as well as deployment and maintenance criteria. The next step was to move to a completely different BIOS core and work from source code to add or remove features so we could meet all the functional requirements and stay within the 15 second time window.

Approach 2

Moving to a new core BIOS from Phoenix involved working very closely with the motherboard manufacturer to de-risk the transition and guarantee a seamless switch for the customer including an arrangement to provide continuous warranty support for the system motherboard. It also involved working closely with the customer to identify any bugs or requirements that resulted from their testing and needed to be added to the scope of work.

This effort was divided to a two-phase development activity:

1- Phase1: Involved developing an Alpha release with the Phoenix BIOS for the motherboard as a proof-of-concept that incorporates missing features as well as many bug fixes. The work was broken down to 3 main activities:

   a. Build Phoenix BIOS for the motherboard

   b. Bring-up and boot OS

   c. Initial BIOS speedup, bug-fixing, test, validation and release

   At the end of this phase, an updated bug list was created and new requirements were identified such as support for 2 different flash devices on the motherboard to accommodate obsolescence.

2- Phase2: This phase included multiple iterations of BIOS point releases that addressed all bugs and new requirements. The BIOS boot time requirement was also redefined to include time to bring up all PCI/PCIe cards. As a result, the new boot time target was reset to 20 seconds. The main activities were:

   a. Bug fixing and adding required features like IPMI Support, Serviceability & Maintenance requirements like updating BIOS, BMC and SDR as well as BIOS crisis recovery

   b. 20 second boot time optimizations

   c. Performing final QA and BIOS validation for delivery to the customer (QA testing, code debug and regression testing)

   d. Final release and customer acceptance testing

   e. End user Acceptance Testing

Challenges

Here is a list of major challenges we faced and had to overcome to deliver a fully functional fast BIOS.

1- **Develop a common BIOS image to support 2 versions of the motherboard**

2- **Support full functionality of custom PCI and PCIe Graphics cards with custom firmware that drive 20 x 20" high resolution monitors**

3- **Support all PCI/PCIe slots and different configurations on these slots including an option in BIOS to enable/disable PCIe lane width validation to support cards in different slots (i.e. a PCIe x1 card in a PCIe x16 slot)**

4- **Implement a full BIOS menu with different screens and support for multiple configuration settings with the default settings defined by the customer**

5- **Include full IPMI and SMBIOS support for system management**

6- **Provide support for maintenance and management tasks including BIOS, BMC and SDR updates as well as Network boot on all network ports – including ports on the MFIO card**

7- **Accommodate crisis recovery support without the need to open X2000 chassis**

8- **Implement a timestamp for BIOS completion including a utility to read it in Solaris**

9- **Support full functionality on all I/O ports on the system and additional PCI/PCIe cards**

10- **Support BIOS upgrade from original BIOS to Phoenix BIOS, Phoenix to Phoenix, and Phoenix back to original BIOS**

Conclusion

The success of this project was only possible through close work with the customer, the motherboard supplier, and the Five9NS Phoenix BIOS partners. This project demonstrates Five9 Network Systems ability to undertake such complex and technically elaborate projects and deliver high quality products to their customers. This fast BIOS exceeds the customer expectations of 20 seconds boot time and boots in only 17 seconds.

About Five9 Network Systems, LLC

Five9 Network Systems, headquartered at the NASA Research Park in Moffett Field, CA, provides server, software, storage and networking products and solutions to meet the exacting demands of systems OEMs, independent software vendors, systems integrators and volume end users, focused on applications in the Department of Defense, Interactive Cloud, Transaction Processing, Digital Cinema Capture / Rendering and Financial Modeling. For more information, visit www.five9network.com or email info@five9network.com.

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