MontaVista 7 Carrier Grade Edition

Carrier Grade Linux for Military and Aerospace

MontaVista CGE 7 delivers reliable, secure, and serviceable Linux to interconnected embedded devices and high performance networks.

In the age of Network Centric Warfare (NCW), networked armed forces have tactical advantage over more traditional counterparts. Military success now depends on the ability to communicate actionable information among command centers, field troops, UAVs, and other military assets. Although new technologies are continually being developed to meet military demands, this transition to NCW has created new uses for existing technologies, a few of which have been used for many years in the commercial realm before migrating into military applications. MontaVista's Carrier Grade Edition 7 (CGE7) Linux offers high performance networking with availability, reliability, security and

Solution Brief

Military and aerospace systems have evolved from single process/purpose applications to multi-core functionality on proprietary OS/interfaces to COTS hardware /commercial OSS software. The rise of interconnected embedded devices in the new age comes with both traditional and recent challenges:

- Deterministic Real-time system while maintaining high performance I/O .
- Increasing adoption of Multi-core and virtualization technologies to reduce size, weight, and Power (SWaP) needs.
- System and network security and the need of long term security adherence through increasing adoption of Common Criteria standards
- Focused emphasis on Fault-tolerance/reliability/High-availability of the modern interconnected systems
- Faster development cycles leveraging commercial OSS software and COTS hardware.
- Upkeep and refresh of legacy applications
- Long life cycle support and maintainability

MontaVista CGE7 is a complete, standard, Commercial Off-the-shelf Linux distribution that has been extensively optimized to provide the performance, security reliability, availability and serviceability required by modern interconnected embedded devices.

serviceability. High levels of fault tolerance are essential for mission-critical military applications such as unmanned vehicles, rugged devices, and military communications. CGE7 meets the demands of military and aerospace programs, providing application portability, dynamic configuration, field maintenance, and real-time performance in a single platform. CGE7 integrates the complete richness of the open source communities.

Challenges and Solutions

The adoption of interconnected devices, opens up multiple challenges for system designers including performance, security, fault-tolerant/resiliency, and serviceability in both device and network context. It is imperative that devices and networks are seen as an integral entity even if they exist on multiple physical devices to really achieve the performance and security goals of the mission. Let us look at the challenges more closely and how MontaVista CGE7 offers solutions that best meet and exceed the needs with-in a native Linux offering.

MontaVista provides real-time performance features in a 100% native Linux platform to meet stringent timing requirements of defense and aerospace companies. Today, developers of embedded devices embrace MontaVista for real-time applications across a broad spectrum of industries: industrial control, instrumentation, medical, even mission-critical roles in aerospace and defense.

To achieve the performance requirements of carrier-grade systems, MontaVista has added new features and modified existing ones to enhance standard Linux, making it suitable for mission critical applications. Attributes of MontaVista CGE7 include the following:

- Offers response latencies on a par with legacy systems and meets emerging requirements
- Uses existing native Linux/POSIX APIs, IPCs, and other community adopted constructs;
- Enables real-time programming in both user program and Linux kernel contexts
- Does not break existing non real-time behaviors or semantics
- Allows reuse of existing board support and device drivers
- Offers sufficiently compelling performance improvements to gain acceptance by the larger Linux kernel development community

Benchmarks have demonstrated that MontaVista's integration of real-time features deliver much lower latency levels than non-MontaVista implementations. Features of MontaVista real-time responsiveness include:

- MontaVista Linux pre-emptible kernel technology (100% native Linux; no double-kernel non-Linux add-ons)
- High-resolution POSIX timers
- Threaded soft and hard IRQ handlers
- Application-level priority inheritance
- Priority queuing
- Robust mutexes
- Futexes
- Userland support
- Preempt_RT

Multicore Resource Management

There is a never-ending pursuit of reduced size, weight, and power (SWaP) in intelligence, surveillance, and reconnaissance (ISR) processing. Traditionally, what's been seen in the ISR application space: Complex, specialty-built systems which tended to be large, extremely high-powered, and difficult to cool. Many of these systems were ground-based; over time, a larger number have moved into the air and into a variety of different platforms such as unmanned aircraft systems (UASs). Today's systems need to be deployed on smaller platforms, making it even more challenging to meet the SWaP targets of traditional ISR platforms. Increasingly, these designs are now based on Multi-core hardware to significantly reduce SWaP and provide maximum ROI without compromising on functionality and security of the systems.

- MontaVista CGE provides multiple options for maximiz-ing resource utilization of multi-core processors. With both AMP and SMP support, along with new partitioning and virtualization technologies, CGE provides significant flexibility to address multi-core applications.

Virtualization and Real-Time

Real-time applications have been designed around highly customized hardware and software, to achieve the deadlines (timing and others) that govern them. This is in contrast to how datacenter driven virtualization solutions are developed (i.e. with standard hardware & software). However, we now find virtualization technology being considered for the real-time application deployments, breaking free of the traditional hardware & software design constraints. Reasons for this are:

- Scalability: Virtualization can help migrate uni-processor Real-time applications to modern multicore design by simultaneously running work-loads (and without having to make any changes to proven legacy code).
- NFV: Cost effective and easier way to

deliver/deploy network functions.

- High Availability(HA): VMs are being used to enable HA, migrating from traditional 1 to 1 dependency of Application / HA / OS / HW

Real-time application needs are somewhat different at times to the mainstream Datacenter driven virtualization solutions. These constraints could include:

- Real-time performance (hard/soft) – Timing, latencies, and determinism
- Memory
- Boot-up times
- Additional IOs (with direct access) then NW & Storage (and at times customized IOs)

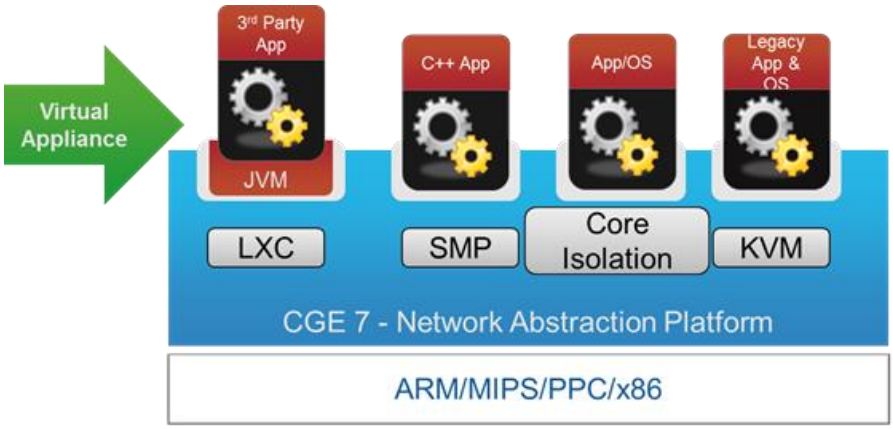
Also, a hypervisor driven approach would also bring additional challenges for Real-time applications, like:

- Guest/Application Isolation.
- Host resource allocation, such as a hypervisor allowing a real-time application to process interrupts directly to avoid adding unpredictable/unplanned latencies.

To achieve multicore and Real-time performance requirements with virtualization, MontaVista offers the following features in CGE7:

KVM Hypervisor

KVM provides a full virtualized environment for hosting multiple guest OS's. KVM allows users to partition the system into multiple OS's with maximum isolation and security. Currently available for all CPU architectures, that support KVM. CGE7 also incorporates the latest KVM



Delivers:
•Platform for virtual appliances
•Dynamic system based on demand
•Power efficiencies and utilization by converging multiple applications on single platform

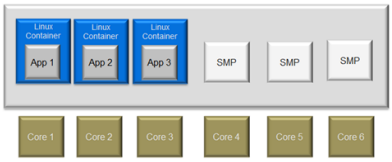
performance improvements and IO pass-through options, including DPDK for Intel and ODP for ARM. .

Linux Containers (LXC)

Linux containers provide an isolated application space without the need for a complete virtualization solution. They are an operating system-level partitioning method for running multiple isolated processes. Containers are not virtual machines, but rather provide a virtual environment that has its own allocated process and network space allowing CPU time and memory constraints to be set.

MontaVista Core Isolation (Capability)

- Achieving, real-time with virtualization requires responsiveness/determinism from the hypervisor. MontaVista has validated techniques with our CGE to achieve this through CPU core Isolation on a multi-core platform. Core Isolation is a technique that allows a task to have the core dedicated to its needs until it exits. In particular Core Isolation uses the power of the resource allocation along with other optimizations to provide a very low-overhead execution environment suitable for high throughput packet handling and other I/O intensive embedded applications. This utilizes the well understood Linux application programming model.

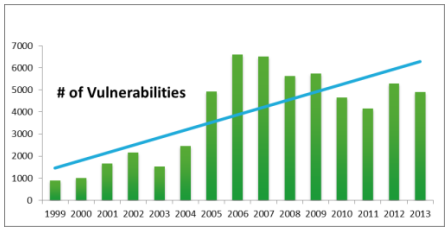


By this technique an application can insulate itself from the Linux kernel scheduler, interrupts, ticks, timers, hrtimers and workqueues. Applications with aggressive real-time constraints need to improve their worst case response time and can achieve this with core isolation. Such application use cases can be networking, HPC or Real time systems. One Example is a Real-time application that is CPU bound (say cyclic test application) . At first you announce to the host scheduler that core-x is not participating in scheduling, using NO_HZ_FULL such that the core can dynamically be claimed and replenished back to scheduler. That core would next be "pinned" to a guest vcpu (usually 1:1 to avoid latencies). Now, one should raise the priority of the Guest process using MontaVista Co-operative Scheduling, whereby the host hypervisor can dynamically raise and lower the guest priority. Additionally, system designers must try to reduce guest-host context switching (i.e. vm_exit) by minimizing page faults, TLB misses, and mapping host and guest vector tables. The result is worst case latency reduced to 10s of microsecond, ***i.e. near native performance***. With the release of CGE7, we have achieved the goal of near "zero overhead" for one or more dedicated core(s) running within MontaVista CGE7. .

Security Enhancements

Security challenges are becoming more complex with the explosive growth of interconnected devices. As device manufacturers across multiple industries are being required to comply with similar Common Criteria requirements, developers are facing new challenges to evaluate and certify products that demand greater security. These needs are even more stringent for military and aerospace designs. Military and Aerospace developers must keep up with current security exploits and patches in order to deploy programs demanding higher levels of security. In addition, military and aerospace companies face increasing difficulty of maintaining many deployed devices over a long period of time, well after repeated updates to the Linux kernel and its packages, including security.

"*The continuous and broad peer-review enabled by publicly available source code supports software reliability and security efforts through the identification and elimination of defects that might otherwise go unrecognized by a more limited core development team.*" - (DoD 2009 OSS memo).



CGE7 has added enhanced Security capabilities in our offering. CGE7 incorporates the critical features that are relevant to the embedded market. CGE7 utilizes the following specifications as a basis:

- Security Technology Implementation Guide (STIG) UNIX version 5.0 r1
- Common Criteria Operation System Protection Profile (OSPP) version 2.0
- Profile for IPv6 in the U.S. Government (USGv6) v 1
- SELinux – NSA/DoD level mandatory access control (MAC)
- MontaVista has worked closely with leaders in enterprise security to create a platform that meets all relevant requirements for the embedded, network, and military/aerospace markets. As a trusted Operating System Vendor, MontaVista receives notification of all security fixes and CGE 7's security team provides rapid updates of any new security fixes to the CGE 7 platform. To further improve uptime availability, Live Kernel Patching has been included in the product. This new feature allows kernel patching of a live system without rebooting the system, giving mission critical programs more flexibility to schedule any down time required for maintenance of a system. Customers can reduce risks, cost, and maintainability by relying on MontaVista to deliver a commercial embedded Linux distribution with built-in security features such as a security hardened kernel with continually monitored secure user space, and secure boot process. .

Fault Tolerance / High Availability / Serviceability

Military and Aerospace systems demand the highest level of fault tolerance with guaranteed reliability and enough serviceability features to ensure that any failures can be avoided, recorded/logged and removed through on-going quality improvements.

CGE adds additional value over open source or proprietary solutions by including features only available from MontaVista. These high value features include:

- Serviceability Features – MontaVista Field Safe Application Debugger, Runtime Application Patcher, kernel crash dumps, flight recorder, live application coredump, microstate accounting, resource monitoring
- Performance Features – real-time kernel with breakable locks for improved latency, interrupt and preemption latency measuring tools, and application loading and locking
- Redundancy Features – Ethernet bonding, application heartbeating and failover, multi-hosted RAID, forced unmount, block device removal, and DRBD
- Networking Features – VRF, IMQ Security Features – IPSec, SELinux High Availability
- Hardware Support – IPMI and SAForum HPI, with support for ATCA , including hot swap management
- Standards Compatibility – PICMG xTCA, Linux Foundation CGL 5.0, LSB 4.1, IPv6 (including mobile IPv6), SA Forum, ANSI and POSIX
- Development Tools – gcc toolchain, gdb, kdb and kgdb kernel and driver debuggers, and a complete, Eclipse based integrated development environment (IDE), as well as memory leak checkers, profilers, the Linux Trace Toolkit, and more.

In addition to these features, MontaVista adds board and architecture support for existing kernel features and backports significant feature functions from future kernels. These features include high resolution timers (HRT), kexec, kdump, EDAC, full NAPI support, full VLAN support, NBD, TIPC, and OCFS2.

All work done by MontaVista goes through at least a peer review process. Work destined immediately for mainstream also gets reviewed in open source as part of the mainstream process.

- In addition to the technical values CGE7 brings, users of MontaVista CGE will benefit from the help of MontaVista's global support organization that can also provide customized support programs for all customer needs. MontaVista will also provide risk mitigation by providing its customers with protection from IP and patent infringement and will provide full US export registration coverage for CGE7. .

MV Professional Services

CGE7 delivers best in class open Carrier Grade technology and is complemented with services delivered by MontaVista's world-class Engineering Services group to assist customers in building solutions to support their specific use cases ranging from porting of legacy applications, custom (or COTS) board support (BSP) , and scalable KVM implementations with real-time performance. In addition to the initial solution, the Engineering Services group can build out a full test and validation process and a long-term support and maintenance strategy to suit the requirements of any deployment strategy. Finally, MontaVista provides standard training courses for getting up-to-speed with all MontaVista products, including CGE7, and features. Customized courses tailored for specific customer environments and needs are available upon request.

Carrier Grade	• 7th generation high quality Linux operating system • Strict QA process, thousands of bugs fixed • Long term support, 10+ year support lifecycle
Architecture	• ARM_v7 & ARM_v8 – BE/LE • MIPS 64 • PPC • x86
Kernel & Tools	• Kernel 3.10 • gcc 4.7, binutils 2.22, eglibc 2.15, gdb 7.4 • Yocto v1.4 • DevRocket IDE – Eclipse v4.2.0
Standards	• Carrier Grade Linux specification 5 • IPv6 certification • Linux Standard Base 4.1 • Yocto 1.4 & Linaro

CGE 7 Benefits

High performance, lower complexity with flexibility

Application developers now can build upon a single OS—Linux—across all of the cores on a multicore processor and avoid the complications of multiple run-times (Linux plus an RTOS) or even an even more complex situation, such as Linux, an RTOS and a hypervisor. With BME & Core Isolation techniques, developers can get the performance of an RTOS, without the cost and overhead of a second OS. They can deliver bare metal performance in Linux, without having to develop kernel optimizations, making the application easier to maintain and secure. . All this with flexibility to decide on the virtualization approach based on use case needs.

Reliable, Future-proof, Long-Term support

Military and aerospace systems have a long life span, and need to be highly reliable and future proof. These are the foundation for which MontaVista Carrier Grade Editions have been designed.

Release Products Faster

CGE7 multi-architecture virtualization capability provides forward porting from your legacy OS, which allows you to update existing products more quickly. And MontaVista's world-class professional services and support teams can offer valuable assistance to help you commercialize a new product idea.

Lower TCO

- Cut your total cost of ownership with a fully supported, standardized Linux platform. The "make vs. buy" decision has been resolved: it simply makes no sense for OEMs to build an operating system when you can acquire CGE7, eliminate concerns about reliability, security, upgrades, or patches, and focus on your value-added expertise in application development.

Success Story

MontaVista was chosen as the supplier for BAEs Naval and Artillery weapons platform.

"*Military customers demand systems of the highest quality, and require support for extended lengths of time. At the same time, BAE needed a development environment that allowed us to rapidly deliver new systems to market to meet the needs of our customers.* "

"*By selecting MontaVista Linux we are able to achieve all these objectives, an open source operating system of the highest quality, rapid development, and long term support from Linux experts.*" - Mikael Alfredsson, Manager Electronics & Electrical Design, BAE Systems Bofors.

Key technical criteria for MontaVista's selection were:

- Real-time response time: gun control loop runs MV Linux and sensor inputs are handled in real-time.
- Ease of development using packaged tooling and platform.
- Military systems have a long life span, and need to be reliable and future proof.
- New system is built on standard processors and COTS hardware, along with some internally developed hardware.
- Recognized MontaVista as a leader in embedded Linux commercialization who could provide the required long term support.
- Selecting Linux over RTOS allowed BAE to leverage the broad Linux skill set in the market.

Summary

MontaVista Linux Carrier Grade Edition (CGE) is a complete, standard, COTS (commercial off-the-shelf)

Linux distribution that has been extensively enhanced to provide the reliability, availability, and serviceability required by carrier grade applications. CGE is derived from the standard set of multiple open source software repositories; MontaVista then adds CGL enhancements from a variety of sources. Most of the CGL specification requirements point to one or more open source projects.

MontaVista has also been a forerunner and believer in bitbake and the OpenEmbedded embedded development paradigm. Now with the launch of the Yocto project, MontaVista CGE7 is fully Yocto 1.4 compatible. This allows MontaVista customers to take full advantage of the existing Yocto/OpenEmbedded ecosystem with its support for added feature layers and hardware support. Others are still being developed and introduced to the open source community over time, ultimately with the goal of inclusion into mainstream distributions such as the standard kernel from kernel.org, various open-source projects, and other distributions. MontaVista compliments the distribution with custom developed features, leading edge development tools, technical support, and professional services.

Next Step

To learn more about the MontaVista Carrier Grade Edition 7 and embedded Linux professional services, please contact your MontaVista account representative at **408-943-4500 or send an email inquiry to info@mvista.com**

About MontaVista Software, LLC.

MontaVista Software, LLC, a wholly owned subsidiary of Cavium Networks (NASDAQ:CAVM) is a leader in embedded Linux commercialization. For over 15 years, MontaVista has been helping embedded developers get the most out of open source by adding commercial quality, integration, hardware en-ablement, expert support, and the resources of the MontaVista development community.

http://www.mvista.com/contactus.php

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