



ACCESS White Paper

Garnet OS: Leveraging the Palm OS Ecosystem with Garnet VM and the ACCESS Linux Platform

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Introduction

To accompany the impressive growth of Linux® as an operating system for mobile devices, and to meet the requirements of device OEMs and operators increasingly deploying Linux, ACCESS released the ACCESS Linux Platform™ in 2006. Based on open source technologies such as GTK+, GStreamer and of course the Linux OS, the ACCESS Linux Platform offers developers a range of resources and APIs for building powerful new devices and application software.

However, mobile/wireless devices are not reinvented with each product generation. Handset designs bring with them a range of legacy functionality that starts in their radio sets and ends with value-added applications and branded look-and-feel. In delivering the ACCESS Linux Platform, ACCESS saw legacy code and requirements not simply as historical artifacts, but as an asset and a huge potential accelerator for new device code and ACCESS Linux Platform-based devices. Why? Because ACCESS' predecessor in interest, PalmSource, Inc., is also the creator of the immensely popular Palm OS® platform (now renamed Garnet™ OS), which a decade after its original launch can still boast an ecosystem of thousands of developers and software vendors, and tens of thousands of applications.

This white paper examines how ACCESS Linux Platform leverages that massive base of legacy Palm OS code by offering the Garnet™ VM¹. In particular, it describes Garnet VM architecture and how it provides the ACCESS Linux Platform with a high level of compatibility with the universe of legacy Palm OS applications.

The Palm OS / Garnet OS Ecosystem

History

Palm OS was originally developed in 1996 to target Palm® PDA devices, built with Motorola® M68000-based DragonBall™ processors. Over time, the Palm OS application space grew to include a range of mobile devices, including handheld gaming consoles, barcode readers, GPS devices and smart phones, with Palm OS gaining support for ARM® family CPUs.

In the course of this decade-long evolution, Palm OS gained a loyal following of end-users and accrued a sizable global developer community. Most impressive were the thousands of Palm OS-based applications developed by individual developers, independent software vendors (ISVs) and service providers.

Garnet OS Today

Eleven years after its inception and launch, Garnet OS enjoys persistent market share in devices from world-class mobile device suppliers. Linux-based platforms like the ACCESS Linux Platform exhibit arguable technical superiority, building on a decade of advances in hardware and software R&D. However, Garnet VM offers device manufacturers the advantage of “market pull” from over 30,000 off-the-shelf applications available from a range of software suppliers and the developer community.

So, while other platform providers and OEMs can only promote their wares on narrow technical merit, OEMs and operators building with and deploying ACCESS Linux Platform can look to Garnet VM as a rich toolbox of ready-to-use applications and utilities, providing solutions to end-user needs.

¹ Garnet OS is the name for Palm OS version 5.4. Garnet VM is a “virtual machine” for running Garnet OS software on other platforms.

Application Type	Examples of Off-the-Shelf Garnet OS Applications
Web / E-Mail	Google Maps™, Snappermail®
Networking	WiFile Pro™, EzFTP
VoIP / SIP	Articulation
Multimedia	Pocket Tunes™, Kinoma®
Productivity	DateBk5, Britannica® Encyclopedia
Games	Bejeweled®, PacMan, Raging Thunder, Sudoku, Village Sim

Table 1 – Examples of Garnet OS applications

Approaches to Leveraging Garnet OS Applications

In creating Garnet VM, the primary objective for ACCESS was to enable existing Garnet OS-based applications to run on ACCESS Linux Platform transparently and unchanged. OEMs, operators, integrators and end-users depend on thousands of Garnet OS-based applications for both productivity, connectivity and for play; ACCESS wanted legacy applications to continue working *in situ* rather than requiring any redevelopment and redeployment.

Options for bringing legacy Garnet OS-based applications forward included comprehensive migration (porting to a Linux-based operating system), source-based rehosting (recompiling/rebuilding from source code to run under the ACCESS Linux Platform), and application platform emulation (execution of legacy binary code on the ACCESS Linux Platform). Given requirements by ACCESS partners and customers for continuity, application emulation proved to be the only viable path.

By avoiding re-engineering and re-architecting, comprehensive testing and QA, Garnet VM emulation for the ACCESS Linux Platform offers developers the lowest cost and lowest risk means to leverage the largest ecosystem of mobile applications in the industry.

ACCESS Linux Platform / Garnet VM Architecture

To understand the form and function of Garnet VM on the ACCESS Linux Platform, it is instructive to start by comparing the ACCESS Linux Platform to the legacy Garnet OS.

Comparing Garnet OS and the ACCESS Linux Platform

Garnet OS inherits many of its capabilities and attributes from the original Palm OS and the CPUs that hosted its execution. Briefly, Garnet OS offers developers:

- Support for M68000 DragonBall, and later ARM processors
- Cooperative multitasking
- Monolithic memory allocation/management with all application and Garnet OS code and data residing in a single (physical) address space
- Simple (*ad hoc*) device interfaces/device drivers
- Limited TCP/IP networking
- Proprietary user interface services
- Compatibility with thousands of Garnet OS-based applications and utilities
- A familiar and mature SDK for device developers

By comparison, the ACCESS Linux Platform brings a range of additional, standards-based capabilities to applications development:

- Full support for ARM architecture and reference hardware from key ARM licensees
- Multi-process and multi-thread architecture
- Process-based memory protection for application code and data with privileged access to operating system resources (kernel, drivers, etc.)
- Formal and well-documented device driver model
- Standards-based (Hiker - Gnome/GTK) user interface services and complete application framework
- Enterprise-class security and networking
- Interoperability with thousands of Linux-based desktop, server and embedded applications

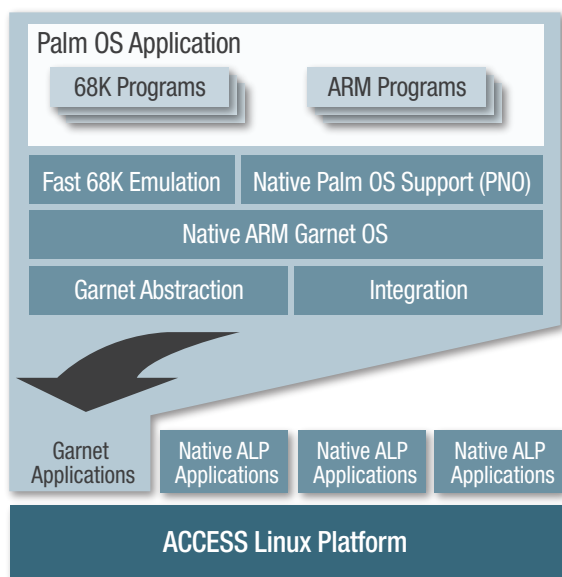
Palm OS was revolutionary for its time, but a modern, enterprise-class OS like the ACCESS Linux Platform brings the robustness, performance and interoperability of Linux to a range of embedded handheld/mobile applications. Garnet OS-based applications running on the ACCESS Linux Platform also share many of the benefits conferred upon native programs.

Garnet VM on ACCESS Linux Platform High-Level View

The Garnet execution environment (a.k.a. Garnet VM) on ACCESS Linux Platform comprises several key components that merit enumeration.

Native ARM Garnet OS

Garnet OS has been running on ARM CPUs since the introduction of version 5.0 in 2002. This release ran natively as an ARM architecture operating system. To support native ARM-based execution of Garnet VM alongside the ACCESS Linux Platform, ACCESS ported Garnet OS to run “inside” a Linux process, effectively as a peer of other native ACCESS Linux Platform applications. As such, Garnet OS runs in a unique (virtual) address space, but runs Garnet OS application tasks as native Linux threads, scheduled on a par with other ACCESS Linux Platform applications.



Garnet OS applications built for ARM processors (like those in Palm Tungsten™ and Palm Treo™ products) run “natively” over this encapsulated instance of Garnet OS, with services and system calls mapped onto underlying Linux services and calls via Native ARM Application Support libraries.

M68000 Emulation – PACE

Most devices running Garnet OS in recent years deploy ARM family CPUs. However, the majority of legacy Garnet OS-based applications are compiled for the original M68000 silicon². As such, Garnet OS v.5.0 also featured an emulated execution environment for M68000/DragonBall code called the Palm Application Compatibility Environment (PACE), and this code lives on to facilitate execution of legacy M68000/DragonBall code in the ACCESS Linux Platform. PACE interprets the M68000 instruction set very efficiently. Typically, less than 20% of application code runs “in line,” with the rest calling into platform libraries and making system calls³.

PACE gains efficiency by mapping Garnet OS services calls into native calls whenever possible (e.g., to process events and notifications, user interface calls, resource management, etc.) From the combination of faster ARM CPUs running the ACCESS Linux Platform and run-time “escape” into native execution, legacy M68000/DragonBall applications can actually run many times faster than they did natively on original Palm hardware, and compared with native Garnet OS code running on ARM hardware.

Native ARM Code (PNO) Support

Garnet VM provides a means for legacy applications to execute native ARM program code when run on an ARM-powered device. The platform provides this capability to allow CPU-intensive applications to be developed (e.g., image processing, audio/video CODEC implementation) without performance degradation from emulating 68000 instructions. These services, also called PNO (PACE Native Objects),

² Some hardware vendors like Palm, Inc. offer value-added applications built for native ARM instruction set execution.

³ Some compute-intensive 68000 applications would actually present smaller run-time footprints by not using PNO.

support capabilities found in native ARM Garnet OS implementations. Garnet VM provides run-time support for a range of such functions present in the legacy Garnet OS environment.

Abstraction and Integration Layers

In turn, both PNO and M68000 emulation calls need to be translated or mapped onto actual APIs within the ACCESS Linux Platform. To ease migration and support, Garnet VM provides abstraction and integration layers to eliminate hard-coded dependencies on ACCESS Linux Platform APIs and also to facilitate shared platform services (e.g., sharing PIM databases) and event processing (e.g., receiving calls, multimedia events, etc.).

Garnet OS User Experience on the ACCESS Linux Platform

The goal of Garnet VM is to support and emulate a useful analog of the Garnet OS user experience. For ease of use and continuity to Garnet OS end-users and other parties, Garnet VM lets users

- Install, run and remove Garnet OS applications, unchanged, as in the legacy environment
- Use input methods as with legacy (touchscreen, pointing devices, 5-way switch)
- Experience events as they would with native Garnet OS (calls, messaging, etc.)
- Share data among Garnet OS and native ACCESS Linux Platform applications
- Set preferences and default behaviors with the same control panels

Capabilities

Garnet VM lets legacy Garnet OS-based applications access and interact with most of the same input/output devices present on both legacy and next-generation mobile hardware:

- LCD Display
- Input with pen and buttons

- Output from audio devices and vibration circuits (battery, etc.)
- Support for limited RS-232, USB, IrDA and Bluetooth® communications through host communication mechanisms (OBEX, etc.)

Improved Reliability

Garnet OS-based application execution is actually more robust and dependable under Garnet VM. By leveraging superior Linux-based memory protection (read-only TEXT/CODE, guarded thread stacks, credentials system, etc.), ill-behaved Garnet OS-based applications cannot impact other software running under the ACCESS Linux Platform. Moreover, Garnet VM is easily restarted with 100% recovery of resources from previous invocations (no memory leaks).

Limitations

ACCESS invested significant resources in building and optimizing Garnet VM to run the vast majority of Garnet OS-based applications under the ACCESS Linux Platform. Tests have shown that about 80% of all such applications run out-of-the-box with full functionality. The remaining applications exhibit some limitations in functionality of background applications, Bluetooth and WiFi, telephony, IrDA beaming and Crypto/SSL; or by their nature cannot run in Garnet VM because of direct hardware access, dependencies on supervisor mode usage and the like.

Support and Validation of Garnet OS Applications

ACCESS' predecessor in interest (then PalmSource, Inc.), acted aggressively to support creation and deployment of Palm OS / Garnet OS-based applications with a mix of developer programs and application validation. Today, ACCESS continues that practice by offering

- Garnet VM, including tools to test/debug Garnet OS-based applications on Linux
- The ACCESS Linux Platform developer tool kit

for building native ACCESS Linux Platform-based application and support application migration (as needed)

- Open Source projects (Hiker, *et al.*) that involve the global open source developer community in enhancing the ACCESS Linux Platform
- The ACCESS Developer Network (ADN)
- ACCESS Linux Platform and Garnet OS certification and signing services

Benefits of ACCESS Linux Platform + Garnet VM

The ability to execute thousands of Garnet OS-based applications out-of-the-box on the ACCESS Linux Platform confers an “unfair advantage” to the platform and the ecosystem around it. Seamless execution of legacy applications offers a range of benefits to developers and ISVs, to device manufacturers, service providers and ultimately to end users.

Benefits	Developers/ISVs	OEMs	Operators	End-Users
30,000+ Garnet Applications		•	•	•
Access to Garnet Ecosystem	•	•	•	•
Preservation of Investment	•	•	•	•
Faster Time-to-Market		•	•	
“Pull” for ACCESS Linux Platform-Based Devices	•	•	•	
Richer Device Functionality		•	•	•
Greater Reliability	•	•	•	•

Table 2 - Benefits of ACCESS Linux Platform + Garnet VM for Different Audiences

Conclusion

In the course of just five years, the impact and growth of Linux on mobile devices and services have been impressive. Going from “zero to hero” involved the work of community and commercial resources working in remarkable harmony. But moving mobile Linux from “darling” status to real commercial success still requires investment from across the mobile ecosystem. As a platform to foster the ongoing progress of Linux in mobile and wireless, ACCESS Linux Platform stands out for its completeness, for its use of standards-compliant building blocks and for its bridging to the open source communities around Linux and the emerging mobile stack. What makes it unique and further distinguishes it from other Linux-based mobile system software is the willingness of ACCESS to embrace the rich Palm OS / Garnet OS legacy, and to build future success on that ubiquitous technology and the ecosystem around it.

Garnet VM serves as a bridge for the many existing Garnet OS developers, allowing them to market existing applications written for Garnet OS while bringing those applications forward to use more powerful native APIs and take full advantage of the capabilities of the ACCESS Linux Platform.



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