

Trend toward Open Systems and Fujitsu's Related Activities

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In April 2005, Fujitsu unveiled its new PRIMEQUEST IA servers. These servers are best-fit solutions for mission-critical applications, with complete openness as a most important characteristic. This paper first examines the history of open systems, and then details the benefits offered to users and the growing popularity of open source software, particularly Linux. The paper then describes the hardware, OS, and middleware of the PRIMEQUEST series from the standpoint of open systems, and finally explains why Fujitsu is so pro-active in the open-systems arena and development of open source software.

1. Introduction

The term “open systems” was first coined in the late 1980s. **Figure 1** illustrates the history of computer systems from the late 1970s to today.

In the 1970s and 1980s, when the use of computer systems expanded very rapidly, each computer company developed its own hardware architecture and OS for its computer systems. Compared with open systems, these systems became known as proprietary systems. Fujitsu and other computer makers developed their main-frame systems and office computers based on such proprietary systems, given the stability and excellent reliability provided in terms of handling user tasks. Consequently, these systems were welcomed by many users, and continued to be even today.

The UNIX system (developed by AT&T Bell Laboratories) enjoyed a wide expansion of use in the early 1980s, particularly among universities and research institutes. With the subsequent formation of a core group of UNIX users in the R&D field, several computer systems incorporating the UNIX OS became commercially available, such as

the workstations of Sun Microsystems. Thanks to the portability offered by UNIX, one of its most important characteristics, computer makers could develop products much more quickly than by incorporating their own OS. Until the early 1990s, UNIX systems spread rapidly throughout the world and platforms based on UNIX became common. Considered “global ecosystems,” such systems soon became known as open systems.

This paper discusses the significance that open systems have for users from the standpoints of hardware systems, OS, and middleware. The paper also examines Linux, whose use has spread rapidly in the past few years, describes in detail the development of open source software that Linux represents, and considers the characteristics of Linux, particularly the significance of having software with publicly available source codes. Based on this discussion, the paper then describes the outlook for the future development of information systems and why Fujitsu is actively supporting the use of open systems and open source software.

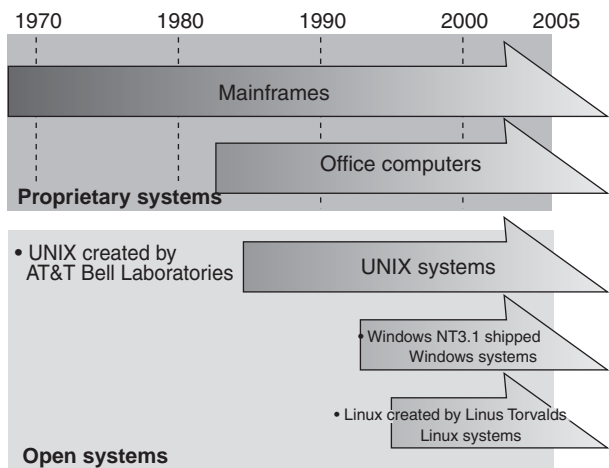


Figure 1
History of proprietary systems and open systems.

2. Increasing need for openness in systems

In the late 1980s and early 1990s, OS functions based on C language (i.e., Application Program Interface or API) became common among open systems that used UNIX as a common technical component. For network functions, these systems shared TCP/IP functions as a common means of accessing a LAN (Local Area Network). Consequently, middleware products like Oracle (DB software) have become easily portable among open systems and a group of global software vendors has been formed. With regard to network connectivity, the use of a network infrastructure that had undergone rapid expansion at the same time based on the TCP/IP functions made it possible to create an environment enabling mutual connectivity among open systems, marked by the use of e-mail, FTP, and telnet, and thus ushering in the age of the Internet.

Open systems came to signify convenience for users, coupled with the openness of computer systems being recognized as a market need. The benefits to users of computer systems that conform to open standards are as follows:

- 1) Users can obtain equivalent open systems anywhere in the world, while remaining free to switch to alternative products.
- 2) Users can compare the products of several vendors for selecting those products that offer superior functions, performance, and price.
- 3) Users can freely choose the most suitable products from among a wide array of middleware.
- 4) Open systems offer excellent network interconnectivity and compatibility with Internet environments.

Although the Microsoft Windows NT operating system and successor systems, such as Windows 2000 and Windows 2003, are Microsoft proprietary systems and not UNIX-based systems, the OS environment is similar to that of UNIX in that these systems have interconnectivity with UNIX systems and can share UNIX middleware. Thus, these systems can be considered as satisfying the requirements of open systems.

3. Open source software

A license to use UNIX source codes had to be obtained to develop the open systems of the 1990s (except for a proprietary open system like Windows NT). However, the OS source codes were such a strictly guarded corporate secret that the codes could not be revealed outside the company. Despite this situation, standardizing OS APIs and network interconnectivity through the standardization of network connection protocols achieved middleware portability.

Then in 1991, Linus Torvalds, a Finish post-graduate student, created Linux and its source codes were released for public use based on conditions in the GNU public license (GPL). This achieved a level of standardization exceeding those of APIs and network protocols that made open systems possible, and open source software soon became the focus of OS engineers throughout the world.

Richard Stallman, who established the Free Software Foundation (FSF) in the 1980s, proposed the notion of open source software. Initially, this mainly meant that individuals, universities, and

research institutions using UNIX systems could freely amend software source codes by using their software skills. However, as the use of Linux began to spread in the late 1990s as open source software, Red Hat and other Linux distributors developed commercial Linux packages that were equipped with installation tools and manuals, which made it easy to install Linux on IA servers. This also made it possible to use Linux without being familiar with OS source codes, and thus created a situation where the use of Linux rapidly expanded in pace with growing Internet use. Corporations welcomed Linux since it satisfied the need for the low-cost, large-scale introduction of WWW and e-mail servers, and because of the liberal licensing conditions for using Linux systems. In the late 1990s, Linux became a standard OS for IA servers alongside the Microsoft Windows system.

Since the Linux OS API and network connection protocol were developed with the goal of compatibility with UNIX systems, Linux achieves a greater degree of compatibility with respect to middleware portability and network interconnectivity among UNIX open systems than Windows.

4. Characteristics of open source software

When Linus Torvalds was creating Linux, the procedure for developing open systems OS changed completely from that used for UNIX open systems. He developed Linux on his own without

using existing UNIX or other source codes, and was thus able to regulate the use of Linux source codes without being restricted by any particular company or individual. Moreover, since he owned the copyright to Linux source codes, Torvalds applied GPL to the use of Linux. This guaranteed that Linux could be used free of charge and the release of source codes for public use meant that OS engineers throughout the world could contribute to Linux development. Consequently, the Linux OS took on the following characteristics, which would not have been possible according to the conventional approach to OS development.

- 1) Linux became established as a basic OS technology that people throughout the world could share. It was adopted as standard material for OS education, which meant that newly graduating computer engineers all possessed a common skill.
- 2) The governments and private sectors of various countries are promoting the use of Linux (**Table 1**). Behind this movement are the intentions to foster a world information technology industry and avoid an excessive dependence on any particular commercial OS.
- 3) Since no particular vendor controls Linux, free competition is ensured with respect to the prices and technologies for hardware and middleware for the Linux platform, thus encouraging cost reduction and technological innovation over the long term.

Table 1
Adoption of Linux in various countries.

USA	Defense Information Systems Agency adopting Red Hat Linux for Department of Defense.
UK	British Government changing procurement systems to Linux based systems.
France	French government and regional public bodies establishing non-profit organizations to share the benefits of developing free source software serving common needs.
Germany	City Hall in Munich switching 14 000 desktop PCs to Linux.
China	Chinese Government promoting the expansion of Linux through Red Flag software, which is highly compatible with Linux, and Asianux, which represents a new approach to the use of Linux.
Korea	Korean government and large corporations promoting the adoption of Linux solutions by switching from UNIX to Linux-based systems.

- 4) Given its neutral position, Linux and other open source software are being used as an environment in which to standardize implementation. For instance, as evidenced by the incorporation of IPv6 network functions, the proliferation of standard specifications has been faster for Linux than for any other OS.

The following sections describe Fujitsu's activities in the field of open systems and open source software.

5. Roles Fujitsu is playing in open source software

Fujitsu is serving the following roles in expanding the use of open source software like Linux.

- 1) **Hardware with greater openness**

Fujitsu is assembling a wide variety of product series, all conforming to open standards and ranging from volume systems with superior cost performance to high-reliability systems used in mission-critical systems.

- 2) **Contribution to open source software development**

Fujitsu is participating in open source software development communities including those for Linux. We intend to contribute to the development of high-quality, highly functional open source software that users will be able to use with confidence.

- 3) **Middleware and solutions**

For the Linux platform, Fujitsu is developing the same wide range of middleware products that are available on UNIX and other open systems, and providing solutions for all types of systems including mission-critical systems.

- 4) **Support**

Fujitsu provides the same level of support for Linux as we have done for conventional mainframe and UNIX systems.

6. Hardware with greater openness - PRIMEQUEST

Since the 1990s when the demand for open systems increased, Fujitsu has developed series of hardware products that are well suited to use with open systems. The following describes our current product series of hardware.

- 1) **Mainframe GS21 Series**

Incorporating a gigabit LAN as standard, this series enables the accessibility of applications utilizing existing software assets in the open systems environment through the use of Interstage application server middleware.

- 2) **PRIMEPOWER UNIX Server Series**

The use of Solaris (the OS occupying the greatest share of the UNIX market) enables the use of a wide range of middleware with network interconnectivity in a high-reliability environment.

- 3) **PRIMERGY IA Server Series**

With both Windows and Linux available, the PRIMERGY series covers the complete range from small servers to high-end servers, and enables both Windows and Linux applications to be freely selected.

In April 2005, Fujitsu unveiled its PRIMEQUEST series of mission-critical IA servers. By maintaining the trend toward open systems set by the PRIMEPOWER and PRIMERGY series, the PRIMEQUEST series achieves a high degree of reliability comparable to that offered by mainframe-class servers.

The following describes the various levels of openness offered by the PRIMEQUEST series.

- 1) **CPU chip**

Adopts the Intel Itanium processor, a high-reliability, high-performance CPU whose use is expanding worldwide.

- 2) **Peripheral devices**

The cost-effective peripheral devices used with the PRIMEPOWER and PRIMERGY series are also available for the PRIMEQUEST series.

3) OS

Both standard Linux and standard Windows enable the special features of PRIMEQUEST hardware. Thus, common worldwide Linux and Windows applications may be freely selected for running on PRIMEQUEST.

4) Networks

A gigabit LAN is incorporated as standard, with a state-of-the-art 10-gigabit LAN also optionally available.

5) Middleware

Middleware that can be used includes Fujitsu's Interstage, Systemwalker, Symfoware, and PRIMECLUSTER, as well as middleware provided by such worldwide Independent Software Vendors (ISVs) as Oracle Corporation, SAP AG, and others.

7. Linux, the open source OS

The following describes the background of systems requiring high reliability (such as the PRIMEQUEST series) in adopting Linux the open source OS.

7.1 Maturity of Linux OS

Since Linus Torvalds first released the Linux OS source codes to the public in 1991, its functions have rapidly matured thanks to the contributions of OS development engineers worldwide.¹⁾ However, though the functions of Linux kernel 2.4 released in 2001 were adequately used on WWW servers and mail servers, there were unresolved problems regarding the expandability and reliability of large scale systems such as the PRIMEQUEST series.

In 2004, the Linux community unveiled Linux Kernel 2.6. Major distributors like Novell and Red Hat subsequently began distributing Linux based on Kernel 2.6, specifically Novell's "SuSE Enterprise Server 9 (SLES9)" in 2004 and Red Hat's "Enterprise Linux 4" (RHEL4) in 2005. The 2.6 version of Linux has fine-grained lock granularity and uses technology that reduces the overhead in parallel operations on large multipro-

cessors. It also incorporates Machine Check Architecture (MCA), which utilizes the reliable hardware architecture of the Itanium processor.

Thus, significant reliability problems have been resolved by incorporating a memory dump function, enhancing the parallel processing of threads, and adding other features jointly developed by Fujitsu and Red Hat, Inc. based on a joint development agreement (signed in May 2003). Refer to "Rapidly Growing Linux OS: Features and Reliability" published in this journal for more details.

7.2 Development community

Since Linux was originally created for PC use, the development community was interested in developing Linux for this purpose. Consequently, some felt that low priority was given to developing Linux to meet the requirements of large servers. However, many members of the Linux development community had intended to use Linux for a wide variety of applications, including supercomputers and embedded systems. This is why the participation of Fujitsu and other computer companies in this kind of development has been welcomed, and by clearly explaining the scalability and reliability requirements for large systems to the development community, those requirements are now being satisfied by standard Linux.

7.3 Linux design considerations

Though the development community accepts easily understandable enhancements, more complex modifications or those involving large development size are not readily taken up. Moreover, since Linux is not a commercial OS, it is designed to be as simple as possible and has no extra functions for assisting other commercial software. This has produced several advantages for Linux. It is a dependable quality system since earnest efforts were made to fix bugs as quickly as possible and any attempt to insert backdoors is practically impossible, thus providing Linux

with enhanced security. In addition, since Linux is hardly dependent on other products, there is little risk of side effects of OS patches that fix problems or OS modifications that enhance OS features, thus increasing the stability in systems using Linux. Such advantages of Linux greatly benefit mission-critical systems like the PRIME-QUEST series.

7.4 Maintenance support for Linux

Linux is licensed virtually free of charge (with only a charge for media) and the Linux development community provides support to users based on goodwill. However, there is no formal assurance for the use of Linux. For this reason, Fujitsu has teamed up with Linux distributors to provide high-level maintenance support for Linux of a degree similar to that offered for mainframe systems and UNIX systems.

7.5 Fujitsu's contribution to the development and promotion of Linux

As a member of the Linux development

community, Fujitsu has been contributing through developing functions for Linux and further improving its quality. Examples of the functions developed by Fujitsu for Linux are given in "Rapidly Growing Linux OS: Features and Reliability" published in this journal.

The maintenance support service offered by Fujitsu is reinforced through cooperation with the Linux community and distributors. Bugs found by users while using Linux are all fed back to the Linux community, thus resulting in further quality improvements. This activity is supported by a kernel mailing list that links Linux development engineers, with much of the communication through this list coming from Fujitsu engineers. In fact, Fujitsu is a major contributor to the mailing list among both Japanese companies and companies worldwide.

Table 2 lists the organizations that are promoting the expansion of Linux and other open source software. Fujitsu is also promoting the use of open source software by working together with these organizations.

Table 2
Organizations promoting open source software with whom Fujitsu collaborates.

Open Source Development Laboratory (OSDL)	A non-profit organization promoting the expansion of Linux use by proposing and designing functions for its application in the enterprise field, for example Carrier Grade Linux (CGL) for telecommunications systems and Data Center Linux (DCL) for enterprise computer systems.
Japan Open Source Software (OSS) Promotion Forum	Its members consist of key Japanese users and vendors of information systems and academic experts in the field. The forum freely discusses problems in the use of OSS and tries to find solutions for them.
Linux Professional Institute (LPI)	A non-profit corporation promoting global standards for the accreditation of Linux engineers.
Japan Linux Association (JLA)	A non-profit organization whose objective is to contribute to the healthy development of the Linux community. Its principal activities are promoting the spread of Linux culture, Linux education and activities for the common good of the Linux community.
PC Cluster Consortium	PC Cluster Consortium is a body that was established for the maintenance and further development of SCore Cluster System Software developed by the Real World Computing Project (RWCP), a project promoted by the Ministry of Economy, Trade and Industry. Its aims are to expand the use of PC clusters and further develop the market for them.

8. Conclusion

In the past, open systems formed the basis of particular ecosystems and developed into an environment where abundant middleware and systems were interconnected. Now, thanks to the contributions of software engineers worldwide, these systems have since been developed into high-performance software ecosystems based on open source software, which extends from the OS level (Linux) to the upper middleware level (e.g., PostgreSQL, Apache).

In the 1990s it was generally believed that the world's computer systems would become PC-based. Now in the 2000s, however, we seem to have entered an age of ubiquitous computer systems due to the tremendous need for high-level systems for a wide variety of applications, ranging from game computers to intelligent household appliances, car-mounted computer systems, and logistics systems.

Moreover, we are approaching a time when compound systems configured from dissimilar

computers that use grid computing networks will be experimented with and put to practical use. Since the requirements for the diverse information systems necessary to control said systems pose low investment cost and offer flexible application, there will be growing opportunities for Linux and other open source systems, due to their liberal licensing conditions and use free of charge. Through hardware products such as the PRIME-QUEST series and the use of Linux and other open source software, Fujitsu intends to supply high reliability information systems that combine Linux and other open information systems. We also intend to continue contributing to the development of open source software as a member of the open source development community.

Reference

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Takashi Kunai joined Fujitsu Ltd., Japan in 1972 and has since been engaged in research and development of OS software for mainframes, UNIX, and Linux. He is now responsible for partner alliances including the relationship with Linux distributors.