

Open Source technology adoption: An exploratory study of the Linux market share

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Abstract

This paper discusses, within the context of the Open Source phenomenon, an issue crucial to the software industry in terms of the dynamics of technology adoption. In particular, it investigates and compares the distinct rates of penetration of the Linux operating system two different markets: in summary, Linux is very competitive in the server market while its presence is still very limited in the mass market, despite its technical features which make it comparable to the MS-Windows standard. The reasons for these distinct penetration rates are investigated, using in particular the Increasing Returns Theory proposed by Brian Arthur and the differentiated characteristics of the Open Source processes of production and diffusion (openness, modularity and cooperative development). Finally, this paper explores the role of the user's technical knowledge of the network topology of Linux processes of production and diffusion.

1. Introduction

In the past decade, the deployment of Free and Open Source Software (FOSS) is a key innovation in the software industry which demonstrates the feasibility of an alternative model of cooperative production, different from the traditional proprietary model of production that has formed the basis for industrial development for over two centuries (Moschella, 2003).

The distinct characteristics of this alternative model are related both to the product and its production process. At the product level, the software is delivered with its source code, and therefore is freely modifiable and redistributable. At the development process level, it is decentralized, and involves, in most cases, the participation of a number of independent developers, often situated around the world. Both the product and the process are governed by special licences which promote sharing as a mechanism to foster innovation in, and the evolution of, software (Weber, 2004).

Linux is the best known FOSS product. In addition to being the most widely used FOSS, it is also the software platform on which the great majority of FOSS products run; for some important applications it is indeed an alternative to the domination of the Microsoft operating system. Like other FOSS products, Linux became a very powerful system which achieved remarkable success in specialized software markets, in particular the server market. However, in spite of its technical and economic advantages¹, Linux remains marginalized in the mass market (referred to as the desktop market), by far the largest market in the computer industry.

This paper investigates the factors that might provide an economic rationale for these distinct penetration rates in the two markets, using in particular the Increasing Returns Theory proposed by Brian Arthur and the differentiated characteristics of the Open Source processes of production and diffusion (openness, modularity and cooperative development). In section 2, the Linux processes of production and diffusion in the specialized market are analyzed, a market where the

¹ According to several independent evaluations (e.g. ZDNet, MOXIE, Bloor Research, MITRE Corporation), Linux would exhibit better levels of performance and less acquisition and operation costs than most Operating Systems. More details in Wheeler (2004).

Linux share exceeds 25%² in some segments such as the server market. Then, in section 3, the desktop market, where the Linux share is under 4%³, is analyzed. In section 4, the server and desktop market processes are compared, and the differences explained on the basis of the adaptability of the FOSS model and the behavioral dynamics of the actors in the two types of market.

2. The specialized market

Like the majority of FOSS products, Linux was originally built by and for computer professionals. Its initial vocation derived from the interests of its principal contributors:

- Linus Torvalds, the initiator and current leader of Linux development, who started Linux in his search for a better tool to solve computer problems;
- GNU project⁴ participants who wanted to replace Unix with Linux as the kernel of their operating system;
- its main promoters, headed by Eric Raymond⁵, who wanted to promote Linux and the FOSS in institutional markets;
- computer corporations (i.e. IBM, Oracle, Hewlett Packard, Novell) that saw in Linux a means of freeing themselves from MS-Windows' dominant position;
- several companies created by independent developers (specialized for the most part in services organizations); and
- its principal users, the corporate software departments where decisions are made by computer-savvy professionals.

Throughout the development of Linux, these various actors formed a group of specialists devoted to addressing technical problems of interest to their community (Kuwabara, 2000). From their contributions, they built an entire toolbox from which they could extract the software parts they needed, adapt them to their needs and give them back to the toolbox to be tested by other professionals. By opening up the code and because of the modular design of Linux, these contributors improved their technical expertise in this software, thereby creating interest groups much like scientific communities (Himanen, 2001; Edwards, 2002). Thus, the Linux developers were integrated into specialized networks (Kirman, 1998), where exchanges allowed them to deepen their knowledge of the various software parts as well as their expertise on these parts.

It is through interacting in this network that participants define the attributes of each of the technology options, as well as the evaluation criteria for each of these attributes. The choices of the technical options and resources are directed, in this way, by criteria based strictly on the technical merits and the adaptation of the options to environments where they are to be used, and, as a result, supporting market diversity (Benkler, 2002). Moreover, the interactions of these independent actors reinforce the decentralized and distributed development of the Linux open system (Cowan and Jonard, 2003; Kogut and Metiu, 2001).

² For instance, in servers connected to the Internet, the Linux market share climbs to 28%, or 2nd place. For more detail, see Netcraft Web site at

http://news.netcraft.com/archives/2003/04/14/netcraft_hosting_provider_server_count_available.html.

³ Molgen (1999), Fink (2003), Ferrary & Vidal (2004).

⁴ The GNU project started by Richard Stallman was the first formal experience of free software, delivered with its source code and a special license called GNU Public License. More details in <http://www.gnu.org>.

⁵ Eric Raymond is one of the founders of the Open Source Initiative and the author of an often quoted study about the Open Source model of development: "The Cathedral and the Bazaar". More details in <http://www.linux-France.org/article/these/cathedrale-bazar.html>.

This type of software development also benefits from the feedback of the participants, each of them taking the components he needs from the toolbox, using them, adapting them, testing them, modifying them, integrating them with other components and giving them back to the toolbox for evaluation. This contribution is then taken by another participant who, in turn, adds information on the parts used and their characteristics, as well as his own evaluations on the participants' performance in the development and evolution of the various components he used. This process makes available to any participant a significant amount of information on the performance of the components, as well as on other participants' expertise, such information allowing them to make enlightened choices on the system and related options (Benkler, 2002).

This cumulative development (Figure 1) led to the construction of a very complete software system, the kernel alone exceeding 3 million lines of code, making it a high-quality system, flexible and adapted to the needs of professional users (Kuwabara, 2000). Consequently, the Linux system is being selected in the server market for its reliability, speed of execution, safety, low relative cost, portability and capacity to evolve with users' computing needs (Wheeler, 2004). This system is also more tailored to technical infrastructure applications, as illustrated by the structure of the FOSS development projects associated with Linux⁶.

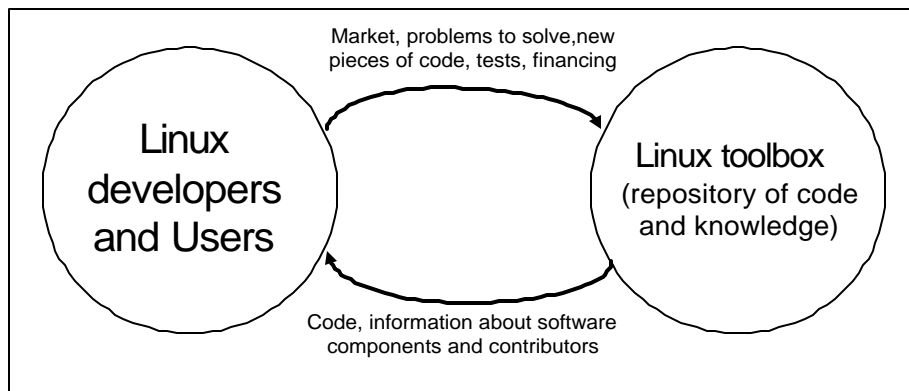


Figure 1: The Linux toolbox production and diffusion processes

The strength of Linux in the specialized market can therefore be summarized by its collective processes of production and diffusion.

3. The mass market

In analyzing the diffusion of Linux, it is easy to see that its procurement in the desktop market is very different from that in the server market. In the former, standardization of the market occurred around a dominant option (MS-Windows operating system and applications using this platform), in parallel with the marginalization of technically competitive alternatives, including the Linux operating system and related FOSS.

The desktop market is not the result of a collective construction process, since, in this market, users have neither the interest nor the expertise to contribute to its development. Linux development in the desktop market is similar to the development of other non FOSS or commercial software, also called proprietary software, where developers are generally not the users of the software: software developers write the programs, integrate them, test them and

⁶ According to the Web site www.sourceforge.net, approximately 70% of FOSS development projects would be infrastructure-related. For more details, see (Feller and Fitzgerald, 2002).

distribute them as a complete package to users who do not have to worry about how the software was produced (Moschella, 2003).

Thus, desktop software is built by a group of professionals who interpret the user's needs, translate these needs into technical specifications and then into the programs. This software appears, in the eyes of its users, to be an "external" object: they do not need to understand the software itself, nor do they modify it or adapt it to their needs. The only thing that these users can do with this software is use it; they do not "own" it in any sense as a creation in which they took an active part, such as happens with the computer-savvy users who participate in Linux server development.

In spite of this, the FOSS community has developed technically competitive packages for the desktop market, as documented in benchmarking studies⁷: with the support of several computing software corporations (i.e. Sun, Novell), this community has developed several versions of Linux distributions⁸ (i.e. Red Hat, SuSE, Mandrake) which compare favorably with Microsoft suites, not only in terms of technical performance, but also in terms of user-relevant attributes, such as user-friendliness and ease of use. Of course, Microsoft suites offers additional benefits, but the magnitude of these benefits is not sufficient to justify the extent of its market share, considering, in particular, the cost differential which is largely favorable to Linux⁹.

The weakness of Linux in the desktop market can therefore be summarized by the lock-in of MS-Windows' dominant position and the marginalization of alternatives, including Linux.

4. Comparative analysis of Server and Desktop markets

In order to be able to explain the differences in Linux adoption rates between the server and desktop markets, we need to acknowledge the presence of nonlinear collective dynamics in the latter market. Unlike in the server market, where individual choices are quite well informed, independent and meritocratic, in the desktop market choices are quite uninformed and majority choices act as inertial attractors. The result is that in the latter market, information cascades and 'herd behavior' drive the market to extreme and persistent market share distributions (cf. Arthur, 1989; Olleros, 1995; Walden and Browne, 2002). Commercial success becomes self-reinforcing and the advantage of a dominant choice becomes almost unassailable. Thus, in the desktop software market there is a considerable market inertia which prevents Linux's progression because most users, accustomed to using Windows for a long time, little informed of the Linux alternative and unable to evaluate the technical attributes of the available options, prefer to play it safe and stay with the dominant platform.

The other actors involved in technology diffusion, in turn, look at user behavior and attempt to synchronize themselves with it in order to facilitate market acceptance:

- Equipment manufacturers, known as OEM (that is, organizations specializing in assembling PCs which constitute the main channel of operating system distribution in the desktop market), look at the choices users make and reinforce these choices in favor of Windows, even though some of them support Linux in the server market (examples: HP, Dell).

⁷ For instance, *eWeek*, *IT-business*, *PC-Magazine*, *ZDNet.com*, *MOXIE*, *CMO International*.

⁸ Distribution is the generic term used to refer to the software packages containing Linux and some tools and applications running on Linux and oriented originally to the desktop market. These packages can be delivered by CD or by Internet downloading. Distribution refers also to the organizations that build these packages by assembling the different software components.

⁹ More details in Foster, 2004, "Linux takes Microsoft rivalry to the desktop", *itbusiness* August 17, <http://www.itbusiness.ca/index.asp?theaction=61&sid=56438>

- Software retailers also observe the behaviors of desktop users and related manufacturers and reinforce their support for the dominant option in place. In the same way, trade journal editors provide more coverage and visibility to information pertaining to MS-Windows-related products.

As represented in Figure 2, these behaviors are governed by network effects that define loops of feedbacks, which, while accumulating, reinforce the choice made by the desktop market for Windows and simultaneously minimizing the market growth potential of Linux. Consequently, the decision logic is developed through mutual reinforcement among the actors and is not constrained by the technical merits of available alternatives.

Thus, in the server market, the network is built on the basis of exchanges of knowledge among experts, while in the desktop market, the users' lack of specialized technological expertise leads to selection criteria based mostly on observation of the majority of market players who adhere to a market standard: they therefore choose on the basis of the choices of other users (in much larger numbers), including suppliers of related technologies.

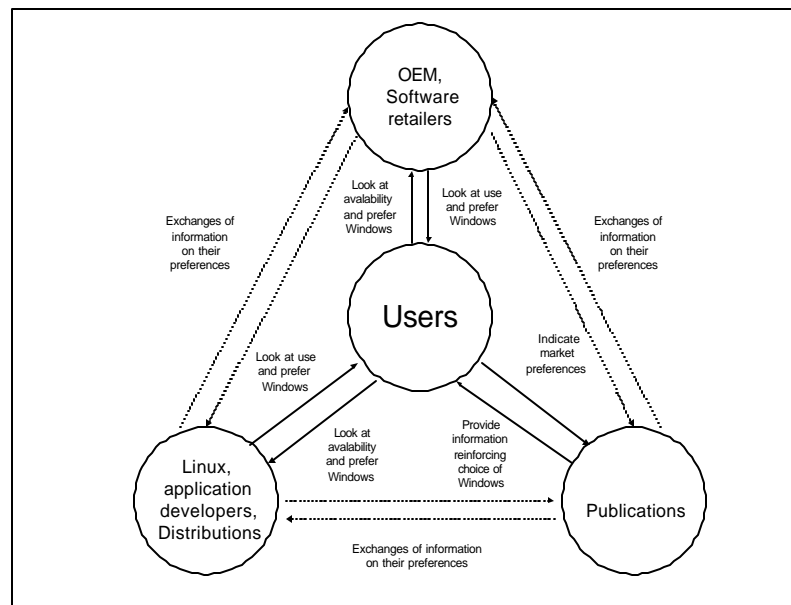


Figure 2: Network effects in the desktop market supporting the lock-in

The network connecting the actors in the desktop market is, consequently, a much wider one, but with much less bounding and the conveying of information which is much less rich than in the server market network. By contrast, in the server market, where the information-rich exchanges allow choices to be made based on the merits of the options, in the desktop market the absence of this richness prevents this type of decision-making rule, which is supported by the extent or totality of the network. And the uncontrollable accumulation of those influences, in the same direction, would support the hyper-selective dynamics and the lock-in of the market, as suggested by Kirman (1998) and Olleros (2002). Such is the case in the desktop market, where the accumulation of this type of decision, which supports the dominant position, beats the path to a single choice (e.g. lock-in), even though the options are technically and economically competitive.

4. Summary and Conclusion

The success of Linux in the server market and its corresponding lack of success in the desktop market cannot be explained only by factors of a technical or economic nature. Their distinct penetration rates have been influenced more significantly by the characteristics of the users, the characteristics of the decisional dynamics and the manner through Linux options are built and provided in each of these markets:

- In the server market, the development of Linux has been a highly distributed effort, with the active participation not only of independent developers but also of specialized users. The driving force was the collective will to create a powerful community toolbox. The resulting positive feedback dynamic has proven to be very powerful: the more contributions arrived, the more solid and compelling the platform became, and vice versa. Not surprisingly, given the high level of specialized skills of participants and the collective emphasis on transparency and quality, the selection process has been very meritocratic.
- In the desktop market, on the other hand, users' lack of specialized knowledge, coupled with their low requirements regarding functionality and high requirements regarding user-friendliness, have fed users' resistance to move beyond Windows. This, in turn has favored the persistence of support for the established standard on the part of all other actors (OEMs, software applications suppliers, retailers, media publishers, etc.). Somewhat paradoxically, then, whereas in the server market users are strongly united by a common goal to develop a better system, in the desktop market they are weakly united by a common interest in preserving the status quo.

Research is being carried out to investigate how to move beyond this extensive lock-in. Avenues being looked at are: collective actions by major users (e.g. major firms or governments having Linux assets) and by Linux developers and supporters. It is postulated that new efforts to create a large number of applications (e.g. multi-media, wireless communication, PDA) in addition to significant performance enhancement favorable to Linux could persuade major potential users (e.g. governments) to adopt it. Moreover, this adoption could foster more development on the one hand and, on the other, send positive signals to even more potential users which could foster further development and still greater adoption of Linux. This could possibly trigger a self-sustaining process of further adoptions and improvements of the Linux desktop platform. Such a process would not necessarily lead to replacement to the current standard by a new standard based on Linux and the FOSS. Instead, this would probably lead to the substitution of the current lock-in dynamics by a new one characterized by a greater diversity and competing options, including the use of FOSS and proprietary software.

References

- Arthur, W. B. 1989. "Competing technologies, increasing returns, and lock-in by historical events", *The Economic Journal*, No. 99, March, 116 – 131.
- Benkler, Yochai, 2002, "Coase's Penguin, or, Linux and the Nature of the Firm", *Yale Law Journal*, V. 04. 3, pp. 369-446.
- Cowan, R. et N. Jonard, 2003, "The Dynamics of collective innovation," *Journal of Economic Behavior and Organization*, Vol. 52, pp. 513-532.
- Edwards, Kasper, 2002, "Epistemic Communities, Situated Learning and Open Source Software Development", Working Paper, Technical University of Denmark.
- Feller, Joseph and Brian Fitzgerald, 2002, "Understanding Open Source Software Development." Addison – Wesley.
- Ferrary, Michel and Pascal Vidal, 2004, "Les bonnes leçons de la communauté Linux", *L'Expansion Management Review*, June, pp. 99-105.
- Fink, Martin, 2003, "The Business and Economics of Linux and Open Source", Prentice Hall.

- Himanen, Pekka, 2001, "The Hacker Ethic, and the Spirit of the Information Age", Random House, N.Y.
- Kirman, Alan, 1998, "Economies with interacting agents", in Patrick Cohendet, Patrick Llerena, Hubert Stahn and Gisèle Umbhauer (ed.), *The Economics of Networks: Interactions and Behaviours*, Springer, pp. 17 - 51.
- Kogut, Bruce and Anca Metiu, 2001, "Open-Source Software Development and Distributed Innovation", *Oxford Review of Economic Policy*, Vol. 17, No. 2, pp. 248-264.
- Kuwabara, Ko, 2000, "Linux: A Bazaar at the Edge of Chaos". *First Monday*, peer-reviewed journal on the Internet, Web site http://www.firstmonday.dk/issues/issue5_3/kuwabara/.
- Moschella, David, 2003, "Customer-Driven IT: How Users Are Shaping Technology Industry Growth", Harvard Business School Press.
- Molgen, Eben, 1999, "Anarchism Triumphant: Free Software and the Death of Copyright". *First Monday*, peer-reviewed journal on the Internet, Web site http://firstmonday.org/issues/issue5_1/molgen/index/html.
- Olleros, F. Xavier, 1995, "Battles for market share in hyperselective markets", in Jagdish Sheth, *Research in Marketing*, Greenwich, CN: JAI Press, pp. 181-218.
- Olleros, F. Xavier, 2002, "Decentralized Open Systems and Monopoly Power in the New Economy", *Global Business and Technology Association Conference*, Rome, 26 June, 15p.
- Walden, Eric A. and Glenn J. Browne, 2002, "Information cascades in the adoption of new technology", in Francesc Miralles, Joseph Valor and Janice DeGross, eds., *23 International Conference on Information Systems*, Barcelona, December 15-18, pp. 435-443. Online at the web site <http://ericwalden.net/research.html>.
- Weber, Steven, 2004, "The Success of Open Source", Harvard University Press.
- Wheeler, David A., 2004, "Why Open Source Software / Free Software (OSS/FS)? Look at the Numbers!", Web site http://www.dwheeler.com/oss_fs_why.html.