Report on Low-Power PC Research Project
Computer Aid International

Introduction

New research initiated by Computer Aid International has identified the preferred low-cost, low-power computer solutions appropriate for rural settings in developing countries.

Computer Aid is the world's largest, and most experienced, not-for-profit provider of practical ICT solutions for international development and has distributed more than 140,000 professionally refurbished PCs in Africa and Latin America.

Computer Aid's PCs have proven to be the most cost-effective computer access solution for thousands of educational institutions and other not-for-profit organisations in developing countries.

However a large proportion of African schools have no access to reliable mains electricity and the costs of solar panels and diesel generators often make IT provision prohibitively expensive.

This research project therefore set out to identify low-cost and low-power computer solutions appropriate to rural settings.

Background

According to the 2007/2008 Human Development Report by the United Nations, the levels of electrification in African countries are extremely low compared to completely Europe. Kenya has only 14% rate of electrification, Zimbabwe 34% and Nigeria 46%.

Even in cases where mains electricity is available, blackouts and failures are common features of everyday life. At the same time the start-up costs of solar are prohibitive and the diesel costs of generators likewise. In response Computer Aid set out to identify whether low-power computers could provide a viable alternative: assessing both purchase and running cost (total cost of ownership).

Computer Aid identified a dozen computers that claimed to require less than 20% of the power used by a regular office PC, thus representing a potential solution for ICT use in rural areas that depend on power from solar panels or diesel generators.

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Although low-power PCs exist they are not yet well known especially in developing countries. The absence of publicly-available comparative research about the features and advantages of the various products had effectively made informed purchasing decisions for schools in Africa practically impossible.

The objective of the research was therefore to conduct professional laboratory benchmark testing of the available low-power PCs and to tabulate product review information of comparative power-consumption, total cost of ownership, performance and suitability for purpose. The aim was to then put the results into the public domain in Africa and Latin America as well as in the UK in order to practically enable informed purchasing decisions to equip rural schools and hospitals.

The project

Of the 12 low-power products initially identified by Computer Aid 7 were tested in the professional product testing labs at ZDNet in London resulting in a short-list of five low-power solutions. These five products were all then shipped to three leading universities in Africa: Kenyatta University in Kenya, Jos University in Nigeria and the National University of Science and Technology in Zimbabwe. The universities were chosen based on their expertise in the field of Computer Science and ICT: all of them are among the regional leaders in this sector.

The five solutions that were short-listed in the London lab included three laptops: **Asus Eee PC, Intel Classmate, OLPC XO**; one low-power desktop: **Inveneo Computing Station**, and one desktop virtualisation solution: **Ncomputing X300**.

Choices were by combining quantitative tests analysing overall power consumption and performance for a set of common tasks usually performed by computer users, including: web browsing, the use of standard office applications and video playing.

Methodology

Field testing PCs at African universities brings a very different set of priorities compared to testing them in a laboratory in the UK.

The availability of reliable mains electricity, usually taken for granted in the UK, is a regular problem in most countries in Sub-Saharan Africa. Both Jos University and NUST Zimbabwe had to struggle with frequent blackouts and inconsistent voltage even during the tests.

A second important difference is even major African universities have access to extremely low bandwidth when compared to the UK. Because of this constraint, it was decided to test video performance of each low-power PCs with a downloaded file, instead than streaming a YouTube video from the Internet, as had been the original test in the UK.

African universities also considered the cost of each solution when making a final choice, a non-decisive element in the UK test, but crucial in defining IT spending especially of learning institutions in sub-Saharan Africa.

About the tests

The tests featured a comprehensive set of quantitative tests, common to all institutions, combined with additional qualitative tests designed and implemented independently in each university.

The quantitative tests were conducted using a professional voltmeter and included power consumption and performance analysis of each solution for the following operations:

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- starting up the PC;
- starting up the web browser;
- using word processor;
- using spreadsheet editor;
- copying a large file from a USB memory stick;
- watching a video in full screen;
- battery duration (for laptops only)

Each university ran multiple instances of each test, in order to be able to extract average reliable results, and to reduce statistical errors.

Qualitative   tests   included:

- installing and testing additional software;
- verifying compatibility with other operating systems;
- connecting to the internet with LAN and wireless networks.

All institutions conducted blind tests without knowing the results or rankings submitted by the other universities. Computer Aid provided technical support during the whole process.

Test Results

The tables below summarise the rankings submitted by each of the involved partners at the end of the testing process.

Power consumption

Kenyatta University	Jos University	NUST	ZDNet
1) OLPC	1) OLPC	1) OLPC	1) OLPC
2) Asus Eee PC	2) Asus Eee PC	2) Asus Eee PC	2) Asus Eee PC
3) Inveneo	3) Intel Classmate	3) Intel Classmate	3) Intel Classmate
4) Ncomputing X300	4) Inveneo	4) Ncomputing X300	4) Inveneo
	5) Ncomputing X300		5) Ncomputing X300

Performance

Kenyatta University	Jos University	NUST	ZDNet
1) Asus Eee PC	1) Inveneo	1) Asus Eee PC	1) Intel Classmate
2) Inveneo	2) Asus Eee PC	2) Intel Classmate	2) Asus Eee PC
3) Ncomputing X300	3) Intel Classmate	3) Ncomputing X300	3) Ncomputing X300
4) OLPC	4) OLPC	4) OLPC	4) Inveneo
	5) Ncomputing X300		5) OLPC

Overall preferred solution

Kenyatta University	Jos University	NUST	ZDNet
1) Asus Eee PC	**1) Asus Eee PC**	**1) Asus Eee PC**	**1) Asus Eee PC**
2) Ncomputing X300	2) Ncomputing X300	2) Intel Classmate	2) Intel Classmate
3) Inveneo	3) Inveneo	3) Ncomputing X300	3) OLPC
4) OLPC	4) OLPC	4) OLPC	4) Inveneo
	5) Intel Classmate		5) Ncomputing X300

Please note:
- Inveneo didn't provide a review unit for testing in Zimbabwe
- Intel Classmate could not be tested in Kenya due to a shipping problem
- ZDNet's overall ranking is based on processor speed and power consumption only, without taking in consideration elements of usability or price
- Detailed quantitative results are available in the Annex of this report

Major findings

Two of the tested solutions emerged as 'winners' of the research: **Asus Eee PC** among laptops and **Ncomputing X300** among solutions based on desktop PCs.

The Asus Eee PC is the overall 'winner' of the tests. It is the preferred solution by all partners. Despite the small size of the screen, it offers the best compromise between power consumption, performance and portability in both Linux and Windows-equipped versions.

The Ncomputing X300 is the preferred solution when setting up computer labs. Despite higher power consumption per each user and limited Linux compatibility, it was appreciated especially by African Universities in the case of installations not requiring portability. Desktop virtualisation can be a viable option to reduce hardware costs, power consumption and required maintenance compared to the use of traditional desktop PCs.

As for the other solutions tested, the Inveneo Computing Station was considered a good option in terms of power consumption and performance, although not as competitive in terms of cost.

The Intel Classmate, despite good overall performance, was not the preferred laptop solution, due to the higher power consumption and lower battery life compared to the Asus Eee PC.

As for the OLPC, it was consistently ranked best for power consumption. However, it was the slowest of all tested systems, and the operating system didn't include software for spreadsheet or video playing. Only one of the universities (Jos) was able to install an external video player on the OLPC. This made it the least popular of all tested solutions.

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Implications for deployments of PCs in Sub-Saharan Africa

Following from the test results, we can imagine three ideal scenarios for power consumption and cost of equipping a school computer lab for **20 concurrent computer users**.

Solution	Asus Eee PC	Ncomputing X300 with refurbished PCs	Computer Aid Refurbished PCs	New PCs
Power Consumption	240W	800W	1900W	1900W
Cost	£3,500	£2,487	£1,780	£8,000

Please note:

- The costs are based on prices in the UK and do not include shipping to Africa.
- The price for Computer Aid refurbished PCs is £39 for a Pentium 4 PC with flat screen (when available).
- The price for the Ncomputing solution is based on:
    - 3x Computer Aid refurbished PC with extra RAM, at £89 each
    - 6x Ncomputing X300 kit, at £175 each
    - 17x extra kit with refurbished flat screen, keyboard and mouse, at £60 each
- The price of new PCs is estimated at £400 per PC

The significant higher cost per user of solutions based on the Asus Eee PC is more than balanced by its very low power consumption, particularly relevant in areas off the mains grid, when electricity need to be generated via solar system or diesel generators.

Solutions based on Ncomputing X300 require over 3 times the amount of power of the Asus Eee PC, but are cheaper and can build on existing hardware equipment in some institutions.

Computer labs based on Computer Aid refurbished PCs are by far the cheapest option (roughly 50% of the cost of equipping a lab with Asus Eee PC laptops), but are less practical in cases where the school is relying on solar power or on a diesel generator.

Brand new standard desktop PCs are the least viable solution for computer labs, both because of the much higher purchase cost and the higher total cost of ownership (when power consumption is factored in).

All universities were quite enthusiastic about the opportunity provided and see low-power computing as a viable solution to provide ICT access to rural under-served areas of Africa.

All participants agree the results of the initiative will help them to inform choices on future ICT procurement within and beyond their institution. They would like to see low-power PCs increasingly used in educational institutions in their countries.

Examples of comments from researchers involved

"As per the tests carried out and analysis thereafter, the Asus had the best solution to an average individual owner and user in Africa who needs a low power PC. Ncomputing is however the most fit and viable in learning institutions. Asus Eee PC was the overall winner for the tests. However, if the solution is meant for a learning institution in Africa, Ncomputing X300 with a high-specified PC is the best solution". **- Henry Kamau, Technical Expert, Kenyatta University**

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"The choice of the Asus Eee PC was strictly considered in terms of power, performance and price. The development of this PCs has also simplified further the use of open source software. It has all modern networking features that can be used in any IT environment. The NComputing X300 series particularly surprised us for the negligible power drawn by an increased number of users. We are likely to use this magic machine in the near future." - **Zuzul Nampak, Technical Expert, Jos University**

Annex – Quantitative Results

Average Power consumption

	Kenyatta Univ. Kenya	Jos University Nigeria	NUST Zimbabwe	ZDNet Labs UK
Asus Eee PC	11.9 W	11.4 W	12.8 W	13.2 W
Classmate PC	not tested	14.3 W	13.8 W	15.3 W
OLPC	6.9 W	7.3 W	8.5 W	7.4 W
Ncomputing X300	36.2 W	39.3 W	32.8 W	29.2 W
Inveneo	19.9 W	21.9 W	not tested	20.7 W

Performance Tests

Average time required to complete full tests

	Kenyatta Univ. Kenya	Jos University Nigeria	NUST Zimbabwe	ZDNet Labs UK
Asus Eee PC	28.1 min	36.8 min	32.9 min	19.9 min
Classmate PC	not tested	42.9 min	34.1 min	17.9 min
OLPC	unable to complete	33.5 min (incomplete)	20.2 min (incomplete)	39.5 min
Ncomputing X300	68.2 min	49.5 min	54.1 min	24.9 min
Inveneo	30.5 min	36.3 min	not tested	31.1 min

Performance Ranking

Kenyatta University	Jos University	NUST Zimbabwe	ZDNet Lab UK
1) Asus Eee PC	1) Inveneo	1) Asus Eee PC	1) Intel Classmate
2) Inveneo	2) Asus Eee PC	2) Intel Classmate	2) Asus Eee PC
3) Ncomputing X300	3) Intel Classmate	3) Ncomputing X300	3) Ncomputing X300
4) OLPC	4) OLPC	4) OLPC	4) Inveneo
	5) Ncomputing X300		5) OLPC

Test methodology

The test run by the African universities included:

– start up the machine;
– open the word processing software, type a short document provided, save it, close the application;
– open the web browser, close the web browser;
– transfer the video file provided (the animation video 'Big Buck Bunny'in 480p, available for download at http://www.bigbuckbunny.org/index.php/download/), open the video player, play the transferred video file in full screen, close the video player;
– open the spreadsheet editor, type the file provided (a basic table) and create a graph with it, save it, close the spreadsheet editor;
– shut down the machine.

The test run by ZDNet at their London labs included:
– typing a short document into a word processor;
– entering three columns of figures into a spreadsheet and creating a graph;
– opening a browser and using Google to find the Computer Aid web site and then open it;
– going to YouTube and playing a 3 minute long video

The average power consumption was measured while conducting the performance test.

All results published are the average result of multiple tests conducted independently by each institution.

The difference in the test design is mostly due to unequal access to Internet available in the African universities which would have made completion of the tests difficult for reasons beyond control of the institutions.

Because of the difference in the tests conducted and because of human factors might have influenced the time required to complete tests, comparing the results of each solution across the different institutions is not fully reliable. The performance ranking submitted by each institution adds further value in comparing results.

Additional information and clarifications on the tested solutions

Ncomputing X300: results are to be considered on a per-seat basis, considering 7 concurrent users, connected through the main desktop PC and the 2 Ncomputing X300 cards. The main PC used by all universities during the tests is a Dell Optiplex DX270 with Pentium 4 Processor 2.8Ghz, 1Gb of RAM and Windows XP SP2, a refurbished PC provided by Computer Aid. All users were using a 15" Dell flat screen monitor. ZDNet only tested the system with 4 concurrent users. Kenyatta University attempted to install Ubuntu Linux and use the Ncomputing X300 under Linux, but the system does not appear to be compatible with any current version of Ubuntu. The significant difference in time required to complete the test with 7 users is primarily due to the limitation of the hardware in playback of full screen video: no more than 3 users can watch the same video in full screen at the same time. In order to reduce the overall time required to complete the test with this unit, NUST and Jos University allowed some of the users to complete other tasks in a different order while 3 users were watching the video.

Asus Eee PC: The data from Jos University refers to the Eee PC 900 model, while all other tests were conducted using the Asus Eee PC 701. In both cases, the laptops were running the standard Linux distribution installed by Asus on the Eee PC.

Classmate PC: The units used for the test by African universities run Windows XP SP2 and have a 8.9" screen. The unit tested by ZDNet is the previous version of the Classmate PC, with a 7" screen.

Inveneo: All institutions who tested this machine conducted tests with both Windows and Linux operating systems. We are however publishing results obtained while using the Ubuntu-based Inveneo Desktop Linux 2.0 installed of the PC.

OLPC: The operating system of the laptop currently doesn't directly support neither spreadsheet nor vide playing. None of the universities could complete the spreadsheet test on the OLPC. As for video playing, Jos University managed to install an external package (mplayer) available on the Internet and to play the provided video with it. Kenyatta University couldn't install the same application and therefore didn't complete the performance test with the laptop. NUST decided instead to test video playing capabilities by first taking a video with the internal webcam of the OLPC and testing performance while playing back the same video. The ranking of OLPC in the test results is at least partially due to the limitations of the software

All results are the average of multiple tests conducted independently by each institution. In the case of the African universities, Computer Aid provided technical support.