Solving the Problem of Limited Access to Original CAD Software for Consulting Engineers in Nigeria and other Developing Countries: A Case for Software Renting/Subscription

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Authors' contributions

This work was carried out in collaboration between both authors. Author CCNO conceived the study and carried out the data gathering and analysis. Author SO helped in the analysis and wrote up of the paper. Both authors read and approved the final manuscript.

Opinion Article

ABSTRACT

Finance is a major obstacle to software ownership in Nigeria and indeed most developing countries. This paper advocates the adoption of software rental/subscription as a way of ameliorating the problem of Computer Aided Design (CAD) software ownership among engineers in Nigeria and other developing countries. A survey of 50 engineers in Nigeria found that 100% agreed that software improves their designs, while 96% of them do not have access to all their software needs. 100% of those who do not have access to all their software needs, identified finance as responsible for their inability to access all their software needs, while 95.74% advocated software subscription/rental as a solution to financial obstacles to software ownership. This study therefore recommends the adoption of software rental/subscription to all CAD software vendors to improve software ownership among engineers in Nigeria and other developing countries. This will be a boost to the design and development of critical infrastructures needed for industrialization, growth and economic development.

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1. INTRODUCTION

Developing countries are largely characterized by low income per capita. According to World Bank classifications 2015 [1], low income countries have Gross National Income (GNI) per capita of $1045 or less, middle income countries have GNI per capita of between $1045 and $4125, upper middle income countries have GNI per capita of between $4125 and $12,736, while the high income economies have GNI per capita of $12,736 or more. The World Bank classifies upper middle income economies and high income economies as developed countries.

This means that the average wage earner in a developed country earns about $4125 or above per annum. This income power is way above the average income of individuals in most countries of the world, where most citizens live on less than a dollar a day. At least 104 countries of the world are classified as developing countries [2]. These countries account for more than seventy eight percent (78%) of the world's population [2].

The implication is that individuals in developed countries have much more purchasing power than those in developing countries. This is the reason why software piracy is prevalent in developing countries, as the citizens who struggle to provide basic needs like food, shelter, medical care etc, would rather spend on their basic needs than on software ownership which they regard as a luxury.

Developing countries are in critical need of infrastructures [2]. Engineers are at the heart of design and construction of critical infrastructures needed for socio-economic development of any nation. Computers and software are critical components of modern engineering practice. Computers and software are absolutely necessary in the design and construction of infrastructures and goods necessary for development.

The use of computers in design, manufacturing and construction is a feature of modern engineering practice. The tremendous advance in computer technology has made computers cheap and affordable. In many developing countries engineers can afford personal computers in the form of laptops and desktops. But in computer systems, the cost of software often exceeds that of the hardware by far. The cost is even much higher when the software is a special purpose software. Computer aided design (CAD) software are special purpose software used by engineers. The cost of such software is often high and way beyond the reach of most engineers and engineering consulting firms in developing countries.

In terms of computer literacy, with exception of engineers trained in the 90s, most engineers in Nigeria were not computer literate prior to graduation. In the 70s and 80s only mainframes were available in tertiary institutions for engineering education and most students rarely use it during their training. Up until the late 90s, most practicing engineers were not exposed to the use of computers. Most engineers in Nigeria started using computers with the introduction of Windows 95 and AutoCAD R13 in the late 90s. The AutoCAD software that most of the engineers use were pirated copies and some of the features do not function well neither do the engineers get technical support from the vendor. With the exception of very few obdurate ones who still use manual methods to do their designs, practicing engineers in Nigeria are computer literate and use computers in their professional practice.

This paper investigates the problems of software ownership among engineers in Nigeria and recommends that software subscription/rental schemes would drastically improve software ownership among engineers in Nigeria and other developing countries of the world.

2. OVERVIEW OF COMPUTER AIDED DESIGN (CAD)

2.1 History of CAD

Computer aided design is a design system which involves the effective use of computers to create, analyze, modify or document a design [3,4]. Computer aided design is usually closely associated with interactive computer graphics.

As is the case with most of computer graphics, the Computer-Aided Design (CAD) discipline can trace its beginnings to the Sketchpad system developed by Ivan Sutherland in 1963 [5]. Sutherland was able to connect the display capabilities of the Cathode Ray Tube (CRT), with

the computational abilities of the computer, and the interactive process made possible with the light pen to create a system for designing mechanical parts. His system was described in a 1963 conference paper [6]. At the same conference, his advisor, Prof. Steven Coons of MIT published an article that laid out the relationship of the computer-aided design system as it evolved from the automatic programmed tool (APT) that was developed from the milling machine that was designed for use with the Whirlwind computer [6].

The work of Sutherland prompted the automotive and aerospace companies to take notice and start their own projects to try to harness the power of the computer for their design needs. One of the most notable programs was the DAC (Design Augmented by Computer) project at General Motors, which was a joint project with IBM. DAC was considered by many as the first computer aided drawing system and was created in 1964 [7].Computer aided design continued to progress through the sixties and seventies with the first generation CAD systems. However these CAD systems run on minicomputers were not very affordable and were limited to research labs and big organizations.

With the introduction of personal computers by IBM in 1977 and Apple (Apple Macintosh) in 1984, which were cheap and had fairly good graphic capabilities encouraged researchers to develop professional grade CAD software for personal computers [8]. This gave rise to second generation CAD systems. In 1982, Autodesk was founded by John Walker. He and the other 15 co-founders set off to develop five different desktop automation applications [9]. They did this with the notion that one of the applications would take off and be developed further. Of all the automation products they developed only one was successful. That successful product turned out to be AutoCAD, which was based on a CAD program written in 1981 by Mike Riddle called MicroCAD. AutoCAD was shown at the COMDEX trade show in Las Vegas as the first CAD program in the world to run on a PC [9].

AutoCAD is a Computer Assisted Design (CAD) software package for 2D and 3D design and drafting. It currently runs only on Microsoft operating systems. Versions for Unix and Apple Macintosh were released, but these met with limited market acceptance and were later dropped. Initially for mechanical engineers, it has been extended and is very widely used by architects and other design professionals [9]. Its

file formats (DWG and its ASCII equivalent, AutoCAD DXF) have become the default standard for CAD packages [9].

The recent progress and advances made in object-oriented programming, artificial intelligence, database management systems (DBMS) and advanced computer graphics are the major features of third generation CAD systems [10,11].

2.2 Design Using CAD Systems

The functions performed by the CAD system are those functions that are normally employed in the design of any product, independently of whether a CAD system is used [3,4]. The basic tasks that are performed using CAD systems include [3,4]:

1. Geometric modeling.
2. Engineering analysis.
3. Data storage and retrieval.
4. Automated drafting.

The stages in computer aided design are:

1. Geometric modeling.
2. Engineering analysis.
3. Design review and evaluation.
4. Automated drafting.

The details of the stages involved in computer aided design are presented in the following sections.

2.2.1 Geometric modeling

Geometrical modeling involves the creation of the mathematical model describing the geometry of an object using the computer. The model is contained in the computer memory. This permits the user of the CAD system to display an image of the model on graphics terminal and to perform certain operations on the model. The most popular software for geometric modeling is the AutoCAD.

2.2.2 Engineering analysis

Frequently objects modeled using the computers are subjected to engineering analysis. The analyses are usually in the form of stress-strain calculations, heat transfer analysis, simulation etc. When modeled objects are subjected to engineering analysis useful design parameters are determined or quantified. Parameters that do not conform to specifications will necessitate changes in object's models. This aspect of CAD

is extremely important and many software vendors market software for engineering analysis, but most of them are quite sophisticated and expensive.

2.2.3 Design review and evaluation

Sometimes there could be many models, and after analysis the model that best satisfies the designer is chosen for presentation or automated drafting. Equally error checking, animation of simulations, ranking/scoring of design etc form part of the design review and evaluation.

2.2.4 Automated drafting

The fourth area where CAD is useful is presentation and documentation. CAD systems can be used as automated drafting machines to prepare highly accurate engineering drawings quickly.

2.3 Benefits of Computer Aided Design

Having reviewed the stages in computer aided design, the benefits of computer aided design are hereby presented. The benefits of computer aided design (CAD) includes but not limited to [3,4]:

1. Simplification of complex behaviour pattern of systems.
2. Significant efficiency improvements in engineering design.
3. Greater accuracy in design.
4. Easier modification of design.
5. Easier storage and retrieval of design data.
6. Easy creation of design database for data mining and decision making.
7. Improved engineering productivity
8. Faster designs and Shorter lead times
9. Reduced engineering personnel requirements
10. Faster response to requests for quotations
11. Avoidance of subcontracting to meet schedules
12. Minimized transcription errors
13. Improved accuracy of design
14. In analysis, easier recognition of component interactions
15. Provides better functional analysis to reduce prototype testing

3. SOFTWARE OWNERSHIP SCHEMES

From the discourse in section 2 above, it is apparent that CAD is invaluable to engineers in

designing efficient and high quality products and services. Having had an overview of CAD, the discussion here will focus on the modes of ownership of CAD software tools for engineers. Software ownership schemes refer to various ways that software vendors make the software they developed available to users. There are several ways of owning software which could either be temporary or permanent (perpetual) [12,13]. These ownership schemes which include open source ownership, ad supported free software, hardware supported free software, software licensing and software subscription/ rental are discussed here.

3.1 Open Source Software

Some software are open source software and most open source software a given out to users free of charge [14]. But open source software are not entirely free because some vendors give them out in return for the use of their services, hardware products or machines [14,15]. Some give out the software for free in return the user pays for technical support and maintenance [14,15].

3.2 Ad Supported Free Software

Some vendors, especially mobile software application vendors, give out software for free, and in return the user sees adverts when using the software [16].

3.3 Hardware Supported Free Software

Some hardware vendors give out free complementary copies of software to users that purchase their hardware or machines. Such hardware includes but not limited to printers, scanners, CD writers, Flash disks etc [17]. Some CAD software are shipped together with some hardware used in CAD as complementary copies. The hardware owners are given complete ownership of the software but the owners have to pay for, sometimes costly, upgrades.

3.4 Software Licensing/ Perpetual/ Permanent Ownership

Most software vendors require users to purchase one or more licenses to use their software on one or more machines. In this mode of ownership, the users have permanent or perpetual ownership of the software [12,13]. This mode of ownership is adopted by most CAD software vendors like Design Expert, Dassault

Systems, Solid Works Corporation etc. The cost of software developed by some of these vendors are shown in Table 1.

Table 1. Cost of perpetual software ownership by various CAD software vendors

Vendor	Cost/License ($)
Solidworks	3995
Design expert	1,295
Civilsoft	10,000

3.5 Software Rental/Subscription

In this ownership scheme, the vendor requires the prospective owners to rent/subscribe in order to use the software. Software subscription was popularized by explosive adoption of cloud computing by several information technology companies like Microsoft, Google, Amazon etc. These companies offer cloud based versions of their desktop software on subscription basis. But these days some software vendors are currently offering desktop versions of their software to users through subscription [12,13].

4. RESULTS AND DISCUSSION

Having explored the utility of CAD in engineering practice and possible means of ownership of CAD software, we surveyed the availability of CAD tools among practicing engineers in Nigeria with a view to finding out their opinion on CAD and the extent of availability and ownership of CAD software and tools by engineers. The engineers were selected at random from all the states in Nigeria. The survey and investigation is quite revealing and underscores the urgent need

for a review of means of ownership of CAD software by Vendors.

Table 2 shows the results of the questionnaire survey of 50 engineers with respect to the utility of computers and software to their practice, and affordability of CAD software for their professional practice. The questionnaire itself is shown in the appendix at the end of the paper.

As shown in the results, 100% of the respondents accepted that CAD software improved their designs. Ninety six percent (96%) don't have access to all their software needs and hundred percent (100%) who don't have access to all their software needs identified finance as being responsible for their not having access to all the software they need. Ninety five point seven four percent (95.74%) who identified finance as being responsible for their not having access to all the software they need advocated the adoption of software rental/subscription as an alternative means of software ownership to ameliorate the financial obstacles to software ownership.

Software rental/subscription is analogous to renting a house where an individual could be sheltered without owning a house. With software rentals/subscription, an individual could have access to some or all the features of the software depending on the nature of the rental. Of course higher rent means access to more features.

Some CAD software vendors like AutoDesk have introduced software rental/subscription while others have not. AutoDesk's software rental/subscription scheme provides a very flexible means to software ownership and maintenance.

Table 2. Result of questionnaire survey

Item description	Number of affirmative answers	Number of non-affirmative answers	Percentage of respondents with Affirmative answers
Does software improve your designs?	50	0	100.00
CAD Improves design to a large extent	11	39	22.00
CAD Improves design to a very large extent	39	11	78.00
Do you have access to all your software need needs?	3	47	96.00
Finance as obstacle to software ownership	47	0	100.00
Advocates of software rental/subscription	45	2	95.74

Individuals could rent/subscribe from anything from one month to 2 years. As a matter of fact AutoDesk has announced that it will stop new perpetual licenses (complete ownership) for individual software products after January 31, 2016 [12]. Even conventional readymade software vendors like SAP and Oracle are now working out plans to make their software and services available to users on a rental basis [13].

Owning software is not always advantageous to the software user since he has to deal with total cost of ownership [13]. The problem of perpetual software ownership is compounded by the issue of software upgrade. This is because the owner has to pay to get an upgrade to the software he/she owns. Sometimes the upgrade could come several times in a year, annually, biannually etc as the case may be. The flexibility that comes with software rental is such that it could fit into any budget, since the user only pays for what he uses [12,13]. Hence, both the rich and the poor could have access to their software needs comfortably. For engineers and consultants, the flexibility is such that they would subscribe when they have need to use the software to design a project, and wouldn't subscribe when they don't have any project at hand. Also, as with house rental where the landlord maintains his property from the rent paid by the tenant, the vendor maintains and updates the rented software for the user, hence, the user is always working with the updated version [13].

As the questionnaire survey revealed, finance is a major obstacle to software ownership in Nigeria. Also, most respondents advocated software rental as a way of ameliorating the problem.

4.1 The Way out for Consulting Engineers

It has been a well established practice for engineering contractors to hire tools and equipment they need to do their jobs. Most contractors, especially small scale contractors, often rent equipment and tools they need to effectively execute their contracts. The cost of equipment hire/rental is usually built into the bill of quantity submitted by contractors while bidding for contracts. It is very expensive for a contractor to own every tool and equipment he needs to execute his contract, hence virtually every contractor hires at least one tool/equipment during the duration of a project.

Quite unlike contractors, the main tool/equipment used by consulting engineers to do their job is the computer hardware and software. As was expounded in section 2, which was roundly backed by my survey results, the use of computer technology and software in engineering practice is invaluable and highly expedient. But my discourse in section 1 brought to the fore the handicap of engineers in developing countries in affording computer software needed for effective consulting engineering practice. As discussed in sections 3 and 4.0, software rental/subscription is a means of software ownership. It is my view that all CAD software vendors should introduce rental as an alternative software ownership scheme even if it means targeting it to a certain category of users, especially consulting engineers in developing countries like Nigeria.

5. CONCLUSION

The world of software is moving to software as a service (SAS) business model. It is therefore imperative for vendors of CAD software to adopt this business model by introducing software renting/subscription.Computer hardware and software are critical to modern industrialization, mechanization and infrastructural development. Improved CAD software ownership by engineers in developing countries will help improve the design and development of critical infrastructures required for growth and development. Hence, it is expedient that critical software needed for engineering designs be made affordable to engineers in developing countries in order to help speed up growth and development in these nations.

DISCLAIMER

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

QUESTIONNAIRE

THE ROLE OF SOFTWARE IN ENGINEERING PRACTICE
Name:…………………………………………………………………………….
Organization:………………………………………………………………………….
Position: …………………………………………………………………………
Tel: ………………………………….. Email: ………………………………….
Could you please tick your answer to each of the questions below. Thanks.
Section A
  (1) Does CAD software improve your designs? Yes ☐ No ☐
  (2) To what extent does CAD improve your design compared to manual design?
      a. Very Low ☐
      b. Low ☐
      c. Large ☐
      d. Very Large ☐
      e. None ☐
  (3) Do you have access to all your software needs? Yes ☐ No ☐

      Section B (For those who answered no to question 3)

  (4) If your answer to question 3 is No, Why?
      a. Finance ☐
      b. Unavailability of required software ☐
      c. Unavailability of required hardware ☐
      d. Others ☐
  (5) If finance is the reason for your answer in item 4, which major CAD software ownership model would you prefer to mitigate the problem of finance. Choose one.
      a. Perpetual ownership ☐
      b. Rental/Subscription ☐