'Building' Architects and Use of Open-source Tools Towards Achievement of Millennium Development Goals.

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ABSTRACT

Millennium Development Goals (MDGs) were established by the United Nations to improve the well-being of humans and their habitat. Whether they are the target beneficiaries or amongst the parties administering services for achieving the MDGs, humans must carry out these activities in a physical environment. Hence, the Seventh Goal of the MDG has an indirect and far-reaching relationship with the others because it deals with the sustainable development of the built environment. Architects deliver consultancy services that span the design, documentation and construction supervision of the built environment. This study sought to determine the extent to which these professionals can do this, with respect to the Seventh Millennium Development Goal, using mainly open-source tools.

The study draws from literature reviews, end-user feedback or reports, interviews with developers of applicable open-source products, and statistics from a survey, launched in 2011, for capturing how architects use ICT in their businesses. Analysis of popular open-source technologies for the Architecture, Engineering and Construction (AEC) industry show a concentration of resources in favour of the later stages of the Architect's role, rather than the design and contract-drawing stages. Some of the better-implemented tools are either too cryptic for professionals who communicate in graphical terms, or heavily biased towards software engineering practices. The products that promise Building Information Modelling (BIM) capabilities are still at an early developmental stage.

Key Words: BIM, IPD, B-Processor, FreeCAD, IFC, ICT, Open-source, Sustainable Development

1. INTRODUCTION

This paper reveals how far an architect in the building industry can go in achieving the seventh Millennium Development Goal (MDG) using open-source software tools. It also exposes challenges in the exclusive adoption of those tools, and the courses of action for inserting them into the professionals' regular tool-kit on a broad scale. This paper also assumes that the audience is familiar with the concept of open-source and open software standards.

To appreciate the line of thought in this paper, one needs to envisage the architect's world, identify the prevalent tasks or goals associated with his role and determine the applicable types of software tools required to fulfil those goals. Depending on the contractual agreement between the architect(the designer), the client (the project owner) and the building contractor or builder – whether the architect is the leader of a team of independent consultants, or in direct or indirect alliance with the construction company, or in consortium with both – there is one common objective, that is to create buildings or structures that efficiently address the clients' needs. His role is mostly characterized by repetitive iteration through the between design, documentation and implementation phases.

As a designer, he combines the 'brief' (the client's requirements), project site conditions, known technology, input from other consultants, market trends, environmental variables and experience, arriving at a polished concept that is both functional and aesthetic. This he does employing mainly visual thinking (Archer, 1979) and bits of experimentation (sometimes involving mathematical thinking). During the documentation phase, information required to reproduce the solution physically is committed to paper. This can be in form of drawings, written instructions, charts, memos etc. During the implementation phase, he supervises to ensure the solution is correctly reproduced within expected time-frames and budget. The need for redesigns or design adjustments may arise when unforeseen issues emerge. This naturally implies updating contract documents, project schedules, and notifying affected parties. Architects are, therefore, designers and construction (or project) managers in their fullest capacity. However, they place greater emphasis on the former.

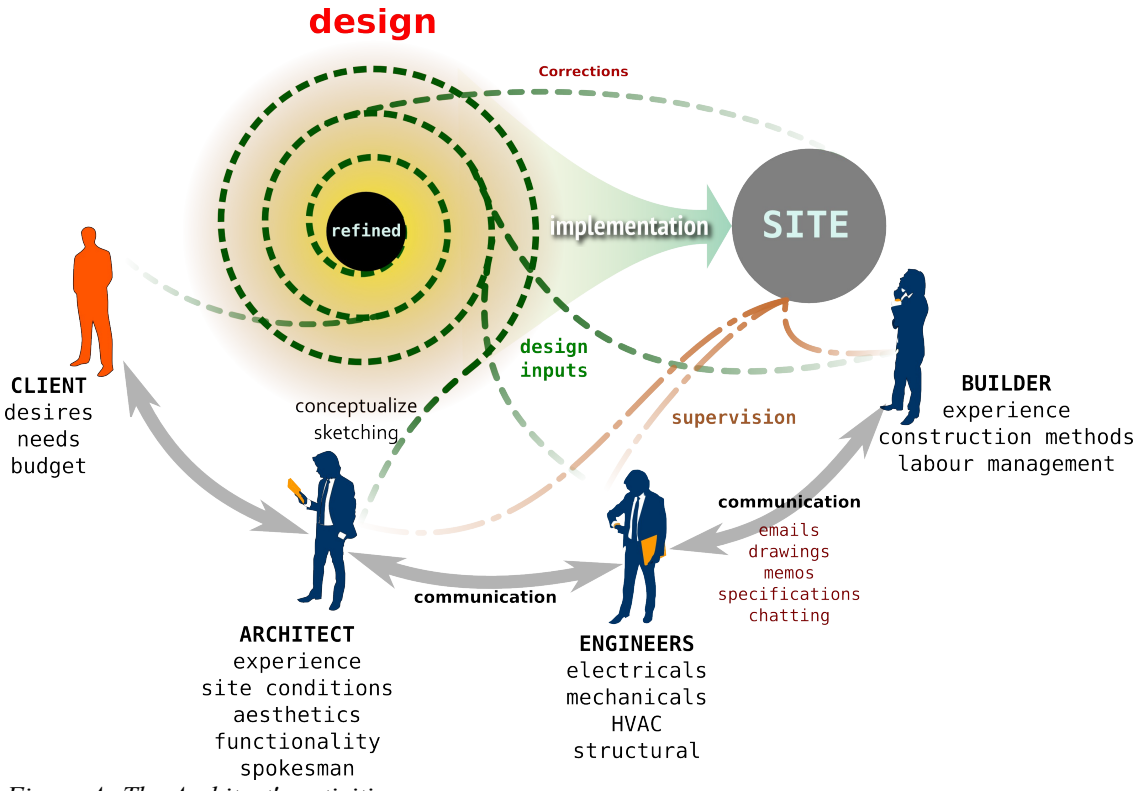

Figure A: The Architect's activities

DESIGN INPUT	DESIGN SYNTHESIS	COMMUNICATION & DOCUMENTATION	SUPERVISION
Cost Analysis	Sketching	Meeting & Chatting	Videos and Photos
Energy/Green Analysis	Modelling	Drafting	Project Management
Videos and Photos	Drafting	Spreadsheets	Calendar
	Visualization	Mailing	Database
		Word Processing	
		Presentation	
		Calendar	
		reporting	

Table 1: Types of Software needed by Architects

Figure A illustrates the architect's web of activities. *Table 1* shows the resultant software types required to carry out those activities. *Table 2 (below)* shows open-source products available to the architect grouped according to the identified software types.

DESIGN INPUT	DESIGN SYNTHESIS	COMMUNICATION & DOCUMENTATION	SUPERVISION
Cost Analysis	**Sketching**	**Meeting & Chatting**	**Videos and Photos**
Gnumeric	MyPaint	Pidgin	GIMP
Gnucash	GIMP	Empathy	Shotwell
LibreOffice-Calc	Inkscape	x-chat	Movie-Player
Energy/Green Analysis	**Modelling and Visualization**	WeeChat	VLC
OpenSOAP	Blender	Konversation	Mplayer
OpenStudio	**B-Processor**	irssi	**Project Management**
EnergyPlus	**FreeCAD**	**Drafting**	Planner
BIM-Server	BRL-CAD	LibreCAD	Taskjuggler
Videos and Photos	**Open IFC tools**	**Spreadsheets**	Git
GIMP	**Drafting**	Gnumeric	Subversion
Shotwell	LibreCAD	LibreOffice-Calc	**BIM-Server**
Movie-Player		**Mailing**	**Calendar**
VLC		Evolution	Evolution
Mplayer		Thunderbird	Sunbird or Thunderbird-Lightning
		Konqueror	Tasque
		Word Processing	**Database**
		Libreoffice-Writer	LibreOffice-Base
		Abiword	MySQL
		Presentation	PostgreSQL
		Calendar	MariaDB
		reporting	

Table 2: Open-source products available to the architect grouped according to software types. Highlighted applications are more relevant to goal-7 of the MDG and for architects using the IPD consultancy approach.

2. OPEN-SOURCE TOOLS FOR ARCHITECTS PURSUING GOAL-7

While *Table 2* is not exhaustive, it is obvious that there is an abundance of open-source software for the architect's documentation purposes. A fair amount exists for the supervision (or construction management) phase. However, for the design phase, the options are limited. For the traditional consultancy approach, where the design and contract drawing documents primarily inform the input of other collaborators, architects can take a business-as-usual approach, using tools like LibreCAD (having roots from QCAD), LibreOffice, Blender, Planner. However, this line-up encourages a work-flow that is fraught with waste of resources because the traditional consultancy approach is less cohesive and less collaborative.

Today, the trend is moving towards a work-flow where the players in the project are brought into play early in the project, and retained until its end. Integrated Project Delivery (IPD) and Lean Design/Constructions are popular

examples. This movement emphasizes success and best-interests of the project over the contributing trades, contrary to the traditional approach where professionals were more cautious and protective of their inputs. The latter often resulted in abandoned projects, litigations and frictions between consultants. The present movement is characterized by collaboration using Building Information Modelling or Management (BIM) software tools to create electronic information that can be accessed either visually of textually by the participants. The approach is to create visual representations of the information in 3D. For the architect, this is usually geometry describing building elements like walls, windows, slabs etc. The virtual objects thus created provide non-visual dimensions like time, mass, manufacturers, and costs through their parameters. Hence, this approach is said to be parametric. The electronic files created by such software become a database for the collective inputs of all parties involved in the Design, Construction and Management of the project. Similarly, green analysis and sustainability tests can be performed on the models using software that can translate the data. Prevalent ones employ a visual modelling approach similar to that employed by the applications used to create the building geometry.

In addition to successful open-source documentation and collaborative tools (for mailing, letters, spreadsheets, web, and chatting), it is apparent that the architect seeking to achieve goal-7 of the MDG needs BIM applications. Popular BIM software are Revit™ by Autodesk, ArchiCAD™ by GraphiSoft, and AutoCAD Architecture™ by Autodesk. These are propriety applications. Free and open-source BIM software tools also exist. ** shows examples like B-processor, FreeCAD, OpenStudio, OpenFOAM, EnergyPlus and BIM-Server. FreeCAD and B-Processor appear to be the best open-source efforts targeted at the architect for the purpose of sustainable development. EnergyPlus, OpenStudio and OpenFOAM address sustainability analysis while BIM-Server aims to address project management (Beetz et al, 2011) and collaboration from design through construction and operation. (Jørgensen et al, 2008). A consortium fashioned after IPD or Lean Design and construction will be interested in all the above solutions, but there are issues that may hinder their adoption in the near future.

3. THE CHALLENGES

Interoperability Issues

B-Processor (Building-processor) promises to be a formidable BIM open-source product. It is probably the most advanced open-source BIM software available to architects. However, the product employs a different approach to describing objects and spatial relationships. In B-processor, surfaces define spaces that may be either habitable or consumed by structural mass (elements), whereas in other popular BIM products, a space is enclosed by objects like walls and slabs, or may need to be modelled explicitly. This difference raises questions concerning the interoperability of B-processor, since the resultant database can only be understood by B-processor. Presently, support for open standards for storing BIM databases like Industry Foundation Classes (IFC) are minimal.

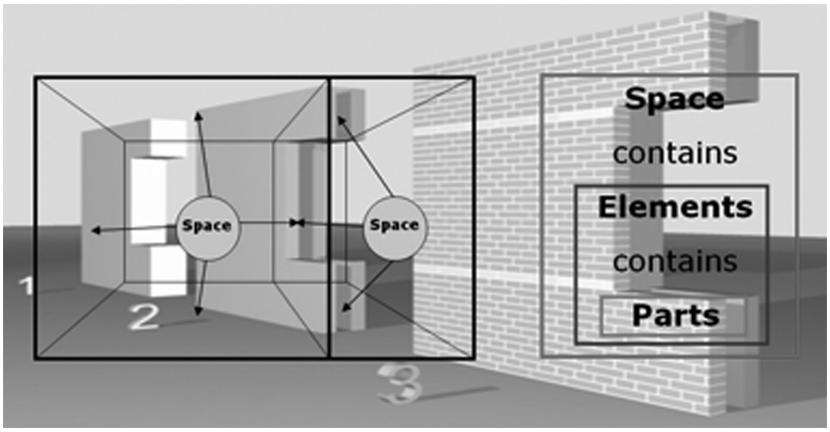

Figure B: illustration of "Spaces" as interpreted by B-Processor

B-processor developers plan to support IFC but at a "low level" (which means with little emphasis on its use) because the relatively more refined data structure of B-processor cannot be translated to IFC format without significant losses (Agger et al, 2007). That discourages the use of other promising open-source products like OpenStudio and BIM-server that are built around the open standard. It also discourages collaboration with parties proficient in notable propriety applications that can read and write the IFC format.

The designers of B-processor recommend that all parties involved in a building project should use their product exclusively to avoid data translation issues (Agger et al, 2007). Popular propriety applications for BIM follow a similar approach. This negates a key principle in the BIM paradigm which is interoperability between applications to maximize collaboration between talents using different products.

Incompletely Developed Products

Another issue with the available open source BIM software that affects its use for creating sustainable buildings in the near future is that it is not feature rich at the moment. A lot of the parts of such software are either experimental, planned or in early stages of their development. A glaring example is the 'Architecture Module' of FreeCAD. It is at a conceptual stage. Although a lot of implementation plans have been discussed, few of those are present in the actual product. This is because there is only one developer working on the architecture module.

Required Level of Computer Literacy

In common with some proprietary software, most open-source software, including B-processor, BIM-Server, OpenStudio and EnergyPlus provide means of extending their basic functionality through scripted plug-in tools. For example, the Architecture Module of FreeCAD is built on the extensibility of FreeCAD via its Python scripting interface. FreeCAD itself provides a set of tools that can be applied to different disciplines. The need to be able alter and automate the basic tools begs the question, "Should architects be software-literate?". While architects today argue that scripting and programming should be reserved for computer scientists, tools like FreeCAD and B-processor challenge that school of thought. Whether architects eventually make scripting a formally required skill or hire a software engineer, a fair knowledge of software engineering is required to get the most out of open source BIM software.

The barrier posed by incompetence in the use of ICT (Information and Computer Technology) extend to other members of the building team *such as the Engineers and Contractors*. Working in a collaborative setting using open-source tools requires that all parties involved should be proficient with those tools and the routines for sharing information over a network. In Nigeria, most of the professionals are yet to appreciate the advantages of effective Local Area Network (LAN) utilization. In a snapshot taken from an on going survey, 23.2% use LAN for file sharing, audio conversation, and chatting. 5.8% are familiar with remote desktop sessions. The rest (71%) favour either the use of CD/DVD and USB drives or ferrying printed documents between office spaces.

4. CONCLUSION

Create More Awareness for Open Standards and Open-source Software

Open-source software is still new to the AEC Industry. If it is to play an active part in achieving goal-7, then there is a serious need for aggressive education on use of these tools. This can be achieved by making existing successful open-source products like Linux and LibreOffice part of school curricula in Architecture schools. The pervasion of pirate copies of proprietary software and the widespread lack of awareness of the associated

legal and moral issues contributes to the slow adoption of open-source alternatives. Until the challenged masses, schools inclusive, appreciate the legal rights of software vendors they will not feel compelled to investigate alternatives.

For example, in the ongoing survey to gather information on how local and expatriate architects use computers, most of the respondents claimed to own a collection of software representing huge amounts in software investment, whereas the same respondents declared an expenditure that is far below the worth of their collection. Meanwhile, 37.8% said they have heard about open-source software, while 80.4% said they do not use it. 9.75% were aware of IFC and those were mostly expatriates. It is apparent that open-source solutions and adherence to open standards needs more promotion amongst architects

Encourage More Cross-Disciplinary Movements.

The recent trend where Architects actively participate in software research and development have resulted in two open-source initiatives exemplified by B-processor and the 'Architecture Module' of FreeCAD. This supports the introduction of programming principles to architects using applicable languages. At present most Universities offer short courses in 'Computer Programming' as part of the Architect's course-ware, but often weak or irrelevant languages like linear BASIC and FORTRAN are the focus. In the survey sited above, 41.3% said they did a course in at least one software development language. Out of those, 54.7% did BASIC, 35.7% did FORTRAN, 4.7% did VisualBASIC (.NET) whereas the leading open source tools are done in JAVA, C/C++ and Python.

Introducing the right basics will pave way for architects to be more involved in fashioning their software tools. At the time of this writing, the 'Architecture Module' of FreeCAD has only one developer (Yorik van Havre). He is an architect and the module is being developed in Python.

Address Mentality Towards Sustainability

Architects today exhibit an unhealthy mentality towards the use of BIM application in general. The models created with BIM applications are being used mainly for visualization and documentation. The architects are therefore harnessing only the part of this new technology that fits into the traditional consultancy approach. This approach, as stated earlier, places secondary importance on designing for sustainability using BIM applications. According to the survey, only 26.8% design for sustainability using their BIM software. Those were mostly expatriate architects practising outside Africa. Reasons given for this trend include:

(a) No one is serious about using such data
(b) The Environmental Impact Assessment (EIA) Experts should handle that
(c) Clients just want to see the way the building will look. Hence, there is no basis to exceed visualization

This trend will adversely affect the achievement the seventh MDG (with or without open-source applications), if they are not addressed.

More Testers and Researchers

The success of open-source solutions depend on the collective momentum of the users and the developers. Users provide much-needed feedback to the developers and sometimes inspire changes in direction and implementation. B-Processor and FreeCAD needs more testers, technical critique and research. It would then be possible that their weaknesses would be resolved fast enough to make them the Architect's primary tools for conceptualizing and designing for sustainability before the expiration of time set-out for achieving the

Millennium Development Goals.

Reconcile Standards

The open source community will benefit if the immutability of data is guaranteed when migrating between open-standards. The B-processor team can leverage the interoperability issues surrounding their product by tendering an errata to bodies defining the building database formats (standards). The next release of the IFC standard from BuildingSMART will, no doubt, be refined and expanded to accommodate omitted details in building structures, yet there should be harmony between the research efforts of the standard bodies and the developers. Where the developers believe to have done a better job, they should communicate their findings to the standards bodies for possible adoption. This kind of collaboration will further establish the viability of dependent efforts like BIM-Server, Open IFC tools and OpenStudio.

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