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SOFTWARE SOLUTIONS FOR DOCUMENT SHARING AND COMMUNICATION IN CONSTRUCTION SME'S



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Glossary

- SME- Small and medium-sized enterprises
- RTD- Rosebud and Thames development limited
- SaaS – Software as a service
- PaaS- Platform as a service
- IaaS- Infrastructure as a service
- ICT- Information and communication technologies
- AR- Augmented reality
- AEC- Architecture, Engineering and construction
- CDE- Common Data Environment.

INTRODUCTION

Construction projects are becoming more complex with so much at stake as company owners try to keep up with the pace of the work and the vastly evolving digitalized world. The growing demand for environmentally sensitive construction means traditional practices must change. While Information technology solutions are being deployed to every other type of business, the construction industry still falls short in terms of deployment and application of the readily available IT infrastructure. The use of information and communication technologies (ICT) can improve business competitiveness, if you want your business to grow, your IT needs grow too, if construction SMEs implement or have access to scalable technologies they could potentially deliver services that in the past only large companies could deliver thereby flattening the competitive arena. Due to their small size, most construction SME's are looking to reduce start-up costs, lower capital expenditures, use services on a pay-as-you-use basis, access applications only as needed, and quickly reduce or increase capacities but face the challenges of affordability of these facilities.

This project investigates the key factors for successful adaption of software solutions for document sharing and communication for construction SME's. I am proposing a solution for an SME I worked for based in Nigeria called Rosebud and Thames Development limited as my case study. I examine the possibilities of deploying these solutions to enhance work efficiency which in turn will help boost their competitive advantage.

Rosebud and Thames Development (RTD) is an architecture / engineering / planning / construction company that specializes in design of buildings, engineering works and real estate development and is based in Port Harcourt, Nigeria. RTD is at the forefront of the construction industry in Nigeria and aims to be a leading player in the nearest future. RTD works with a selected number of trusted general contractors and has a total workforce of 20 people consisting of managing director, architects, site engineers, quantity surveyor, accountant and secretary. Most of our construction sites are based in remote areas far away from the company's office.

PROBLEM ANALYSIS

The company balances back-office functions—materials inventory, site visits, paying invoices, running financial reports, planning logistics—with the physical presence needed on the job site or in an office. Many workers need better access to company data to aid in timely, well-supported decision making and reporting while working in the field. Today’s technological solutions must be able to serve users in both work settings. Some of the challenges facing RTD are as follows but not limited to:

State of IT infrastructure and capabilities:

We are working with a technology backbone that is extremely outdated and inefficient.

Hardware and network infrastructure:

1. The company relies on traditional client/server software which is a windows small business server to provide IT resources to its staff.
2. Weak file sharing protocols, and as a result of working in remote sites, data was often saved on users computers and uploaded when we got back to the cooperate office.
3. Remote offices and sites were disconnected from main server. Reason was that there were no cost effective solutions for the company to move forward.

Software solutions:

1. Separate financial reporting software, cost accounting, project management and estimating solutions were done mainly in excel so we had users getting data from various sources and building up individual excel spread sheets which made it hard to update and track performance.
2. Multiple data entry steps for most processes.

Recording and tracking of flow of information:

It is a requirement for information to be readily available to workers whenever they need it without delay. Issues such as tracking document approvals, Email storage, Remote access and Project information were raised during my time at the company. There were no company or department wide shared calendars. Files were often e-mailed to users for review and revisions and on several occasions, sensitive information was shared to employees outside of a project group or team due to improper use of email groups. After several complains to the management, it was realized that the company employed several different methods of centrally storing data, which varied almost by department and team.

Lack of maintenance information:

In a large construction project running over a long period of time, a significant volume of information is generated, after project hand over and throughout the lifetime of the building, there is a constant need to maintain the equipment within the building and the physical structure in order to successfully adhere to performance reviews. Unfortunately there are times when emergency repair work needs to be carried out due to a sudden failure in a system. This initiates the search to find the information relating to that piece of equipment and normally the amount of time spent looking for warranty or repair data can sometimes far outweigh the amount of time in

actually carrying out the repair work. Due to the downtime, this can lead to more costly alternatives being implemented in order to align with performance standards and avoid penalties, which in turn poses a financial loss to the company.

Reluctance to change:

This is a huge challenge facing the AEC sector as a whole which has a history of following traditionalist procedures to achieve their goals. This approach leads to projects being carried out in a slower and streamlined manner. Organizations resist innovation-and those that do inevitably fail-because people are more comfortable with what they know than with what they do not. [1] For RTD's business to grow, successful implementation of new processes will require a concerted change management effort. There has been a lot of interest around cloud computing during the last couple of years and despite many perceived benefits, many organizations seem to be still conservative regarding the migration to cloud. [2] Fear of the unknown also plays a part in the reluctance as workers who lack the necessary IT skills don't know what to expect and just aren't willing to commit time and energy to do it because they feel the company is running just about fine without it.

Fragmentation:

The AEC industry especially the construction industry is a diverse and fragmented one with many different disciplines working within their own agenda which lends itself to a perpetuation of this fragmented nature with the inevitable result of a breakdown in communication at all levels. Due to increasing specialization and fragmentation within the industry, no single individual has the capability to undertake the overall design and construction of a facility. An example for RTD was during the construction of a private chapel, with a lot of sub-contractors involved, changes by several reviewers had to be coordinated and updated and communication of critical drawings and specifications to the field were often scanned and printed, should changes take place which they often do, getting the new version to the workers resulted in downtime. We faced challenges with our estimating solution as being nationwide company, we would get opportunities to bid work e.g. drawing specifications and tenders and put together a takeoff and start to create an estimate and send it out to various people throughout the country who knew how to build a particular segment of work in the job for review and revision, all which will come back to a central source and need to be re-coordinated and updated. It was an extremely ineffective solution for putting estimates together and ultimately difficult to give our customers the best proposal.

PROJECT OBJECTIVES

A number of objectives are listed out below; they are created with the aim to guide this research:

- 1) Briefly discuss cloud computing and its role in SME's
- 2) Simplify project management and team communication
- 3) Enable growth by using technology effectively
 - a) Real time collaboration
 - b) Single source for all documents (drawings, specifications, presentations etc.)
- 4) Eliminate inefficient Process.

CLOUD COMPUTING

Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model is composed of five essential characteristics, three service models, and four deployment models. [3]

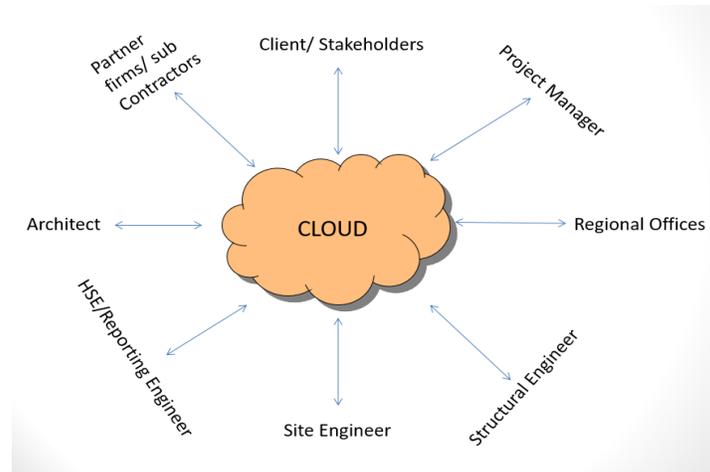


Figure 1 Example of a Construction SME cloud structure

CHARACTERISTICS OF CLOUD COMPUTING

Cloud computing has a variety of characteristics, with the main ones being:

1. **Shared infrastructure:** uses a virtualized software model, enabling the sharing of physical services, storage, and networking capabilities. The cloud infrastructure, regardless of deployment model, seeks to make the most of the available infrastructure across a large number of users.
2. **Dynamic provisioning:** allows for the provision of services based on current demand requirements. This is done automatically using software automation, enabling the expansion and contraction of service capability, as needed. This dynamic scaling needs to be done while maintaining high levels of reliability and security
3. **Network access:** needs to be accessed across the internet from a broad range of devices such as pcs, laptops, and mobile devices, using standards-based applications (for example, ones based on http). Deployments of services in the cloud include everything from using business applications to the latest application on the newest smart phones.
4. **Managed metering:** uses metering for managing and optimizing the service and to provide reporting and billing information. In this way, consumers are billed for services according to how much they have actually used during the billing period.

DEPLOYMENT MODELS

There are four different deployment models of cloud computing:

1. **Public Cloud:**

Public or external cloud is traditional cloud computing where resources are dynamically provisioned on a fine-grained, self-service basis over the Internet or VPN and or from an off-site third-party provider who bills on a fine-grained basis.

2. Community Cloud:

If several organizations have similar requirements and seek to share infrastructure to realize the benefits of cloud computing, then a community cloud can be established. This is a more expensive option as compared to public cloud as the costs are spread over fewer users as compared to a public cloud. However, this option may offer a higher level of privacy, security and/or policy compliance.

3. Hybrid Cloud:

Hybrid Cloud means either two separate clouds joined together (public, private, internal or external) or a combination of virtualized cloud server instances used together with real physical hardware. The most correct definition of the term "Hybrid Cloud" is probably the use of physical hardware and virtualized cloud server instances together to provide a single common service. Two clouds that have been joined together are more correctly called a "combined cloud".

4. Private Clouds:

Private clouds describe offerings that deploy cloud computing on private networks. It consists of applications or virtual machines in a company's own set of hosts. They provide the benefits of utility computing -shared hardware costs, the ability to recover from failure, and the ability to scale up or down depending upon demand. [4]

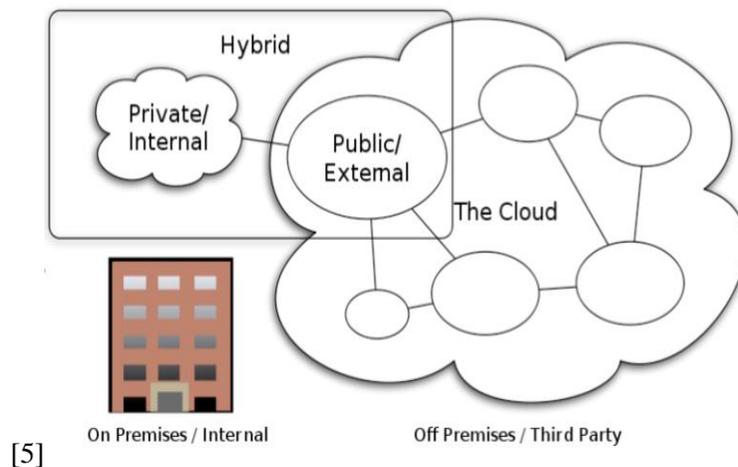


Figure 2- Cloud computing types

SERVICE MODELS

The cloud community has extensively used the following three service models to categories cloud services:

1. Software as a Service (SaaS)

A SaaS provider gives subscribers access to both resources and applications. SaaS makes it unnecessary for you to have a physical copy of software to install on your devices. SaaS also

makes it easier to have the same software on all of your devices at once by accessing it on the cloud. In a SaaS agreement, you have the least control over the cloud. [6]

2. Platform as a Service (PaaS)

Here, a layer of software or development environment is encapsulated & offered as a service, upon which other higher levels of service can be built. The customer has the freedom to build his own applications, which run on the provider's infrastructure.

3. Infrastructure as a Service (IaaS)

IaaS provides basic storage and computing capabilities as standardized services over the network. Servers, storage systems, networking equipment, data center space etc. are pooled and made available to handle workloads. The customer would typically deploy his own software on the infrastructure. [7]

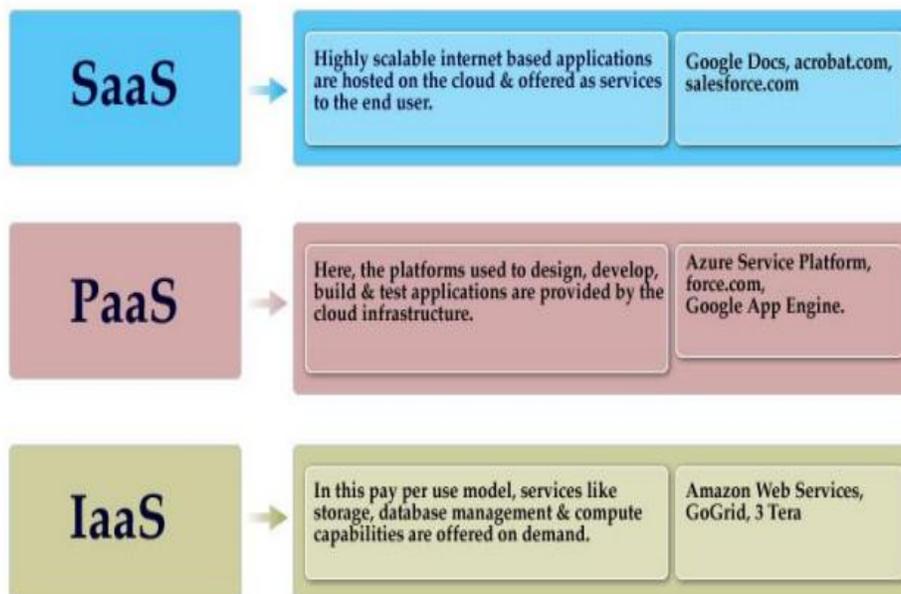


Figure 3: Cloud models

Benefits:

Some of the promised benefits from cloud computing can be very appealing for SMEs, which need to maximize the return on their investment and still remain competitive in the market.

1. **Accessibility:** Services are delivered over a network and are accessible through any device or location. This facilitates remote working arrangements and is consistent with the increasingly globalized nature of doing business.
2. **Low total cost ownership:** Companies can reduce their capital expenditures and use operational expenditures for increasing their computing capabilities. This is a lower barrier to entry and also requires fewer in-house IT resources to provide system support.
3. **Scalability/Flexibility:** Companies can start with a small deployment and grow to a large deployment fairly rapidly, and then scale back if necessary. Also, the flexibility of cloud

computing allows companies to use extra resources at peak times, enabling them to satisfy consumer demands.

4. Maintenance: Cloud service providers do the system maintenance, and access is through APIs that do not require application installations onto PCs, thus further reducing maintenance requirements.
5. Portfolio resource allocation: With the use of clouds, the client/ owner can properly assign duties to the workers in a more centralized location.
6. Supports various file types and applications:
7. Remote connections for teams across multiple locations: construction projects by their nature are geographically dispersed, the use of a cloud system will aid better communication between various parties involved in the process, from the architect to the design engineer on site to the contractors supplying materials.

Concerns

The idea behind cloud computing is that software and hardware services are stored in "clouds", web servers rather than a connection of standalone computers over the Internet. Cloud computing is still in its initial stages and like every other service of this scale and complexity there are fears about the technology's maturity.

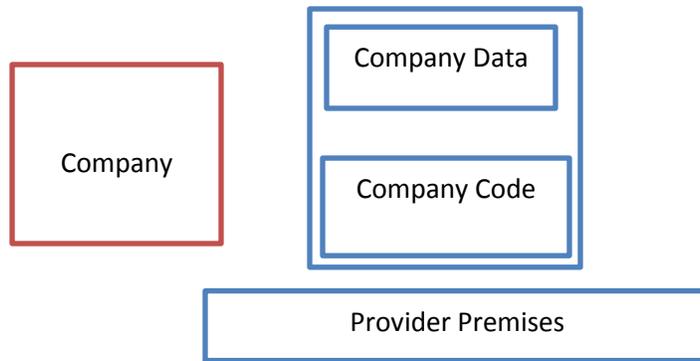
1. Security issues

One of the primary concerns with the use of cloud is data security, as there are no 100% secure systems. Some experts have raised concerns about data privacy and security associated with unauthorized access and use of information stored in the cloud for malicious purposes. [8]

Confidential documents stored on the cloud from the company can become vulnerable to attacks by their competitors or spied by the government. Various attacks such as social engineering attack, XML signature wrapping attack, malware injection, data manipulation, account hijacking, traffic flooding, and wireless local area network attack are instances that have been recorded over the years and pose a great risk to cloud computing systems.

2. Loss of control

The company relies on the provider to ensure data security and privacy, resource availability, monitoring and repairing of services and resources. Also User access control rules and enforcement, data, applications, resources are all managed by the cloud provider.



3. Lack of standard: The lack of established cloud standards and interoperability has made it difficult to move workloads between private clouds and public clouds.
4. Multi tenancy issues: Multiple independent users share the same physical infrastructure.
5. Disaster recovery situations: There needs to be confidence that there will be continuity of business and services if a disaster occurs in the cloud service provider's production environment
6. Auditability and forensics: Difficult to audit data outside of organization in the cloud also forensics are now made difficult since the company does not maintain its data locally

COMMON DATA ENVIRONMENT (CDE)

A CDE is defined in British Standard 1192:2007 as "a single-source of information for any given project, used to collect, manage and disseminate all relevant approved project documents for multidisciplinary teams in a managed process" [9]. It may use a project server, extranet, a file-based retrieval system or other suitable toolset. Creating this single source of information facilitates collaboration between project team members and helps avoid duplication and mistakes. No one wants to change their work process needlessly, fill out the same information multiple time, waste time searching for information, or pay for new technology expenditure where claimed benefits are not clearly defined. By building the asset in a virtual world under the ethos of BIM (Building Information Management), teams can reduce the cost of rework and poorly thought out or executed designs. A simple example of this would be the client, after reviewing the virtual asset, realizes that he/she needs something different to what was originally proposed. A CDE provides a platform for these changes to be recorded, distributed and resolved at a lower cost, resulting in a more efficient delivery team and a happier client. The CDE itself is not a project management tool though can be used with one or many such tools.

Ownership of information within the CDE remains with the originator of that information. Individual models produced by different project team members do not interact, they have clear authorship and remain separate. This means that the liabilities of the originators are not changed by the incorporation of their model into the federated model. There may be complications however where ownership changes as the project progresses, for example replacing design team objects with specialist sub-contractor objects.

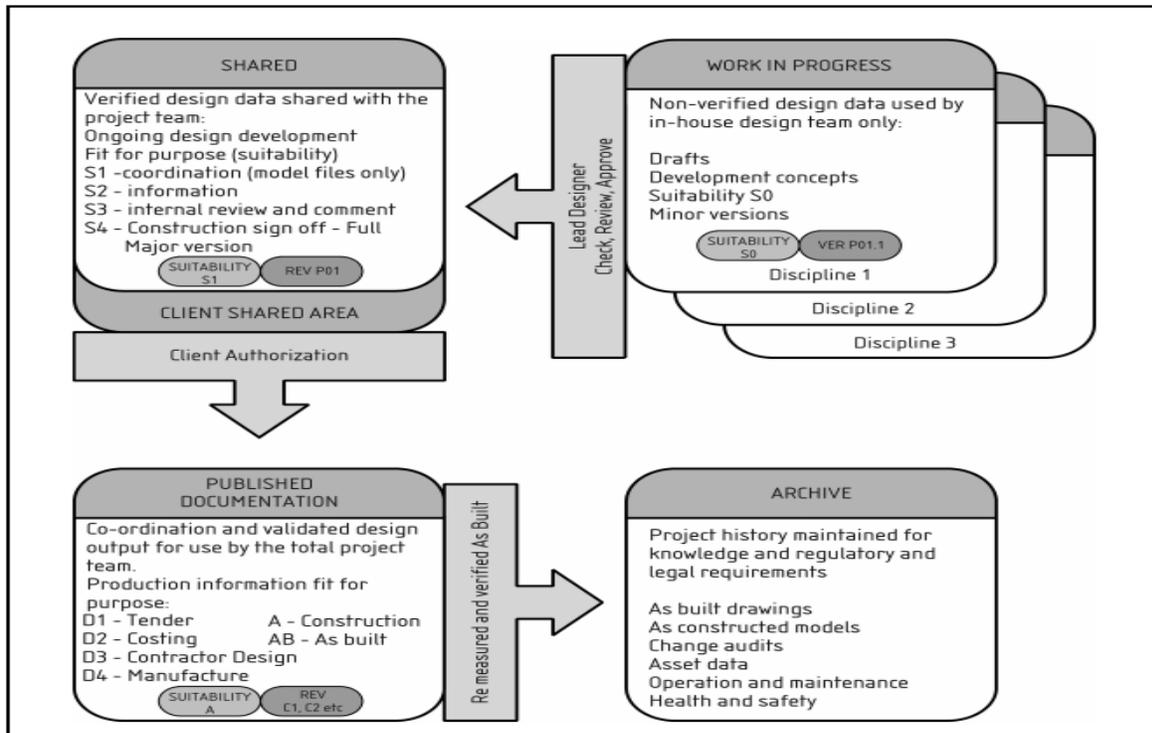


Figure 5 CDE states

The advantages of implementing a CDE Include:

1. Ownership of information remains with the originator, although it is shared and reused, only the originator can change it.
2. Shared information reduces the time and cost in producing coordinated information.
3. Any number of documents can be generated from different combinations of model files.
4. Re-use of information to support construction planning, estimating, cost planning and any other activity associated with building development.

Implementing a CDE in the company will need a lot of staff training involved because you will need upskilled people to plan, implement, manage and support this way of working. This investment will reap huge benefits in the future as the industry is moving towards this direction.

PROPOSED SOLUTION

I am proposing to establish a more centralized and efficient cloud based document sharing system easily accessible to all parties involved. The solution I am recommending is Google G suite.

ABOUT GOOGLE G SUITE:

This cloud-based service acts as a central hub and will be used to replace the old system lacking reliability, support, and scalability and also to maximize agent independence and client support with easy-to-use, easy-to share communication and collaboration tools. It covers a wide variety of features which addresses the day to day issues faced in the running of a project. Taking a look at the individual components will give a better insight on how they perform.

Workplace Implementation:

Hosted email service:

All company emails will be transferred from the intranet based platform to the cloud. Using the G suite Email for a business account will bring our staff under one digital roof where the administrator can create and delete employee accounts, monitor activities, and manage user permissions. By linking our staff with this business email set up, our company will have ownership of emails linked to our domain. This will prevent any conflict with departing employees. When they leave, their password can be changed and any incoming emails are forwarded elsewhere. Creating email addresses for entire departments and assigning task will now be possible with group email addresses. This allows emails to go to every member of that department without individually entering emails. This will equip the company with an email solution that will further enhance and secure email communications. Additional benefits include mobile device management- this allows the administrator to easily locate devices, require passwords, and erase data if needed. Also security options like 2-step verification and single-sign-on (SSO), all from one centralized admin console is enabled.

File Storage:

Google drive will be used to store and back up all company sensitive data such as reports, spreadsheets, evaluation forms, safety procedure documents, employee inventory list, financial audit documents etc. Drive has unlimited storage capabilities that come at a relatively low cost which will be more than suitable for the company of this size. Different access rights will be created by the IT administrator and workers will be able to see who has rights to any document. Google drive will be implemented as a viable cloud storage solution to host collaborative shared Revit models and CAD drawings. Here workers can send, view and leave comments on drawings which can be easily accessed from desktop and mobile devices. This system is fully encrypted and very secure as it comes with data loss prevention for its drive while meeting the company's data compliance needs and are stored on servers in secure data centers.

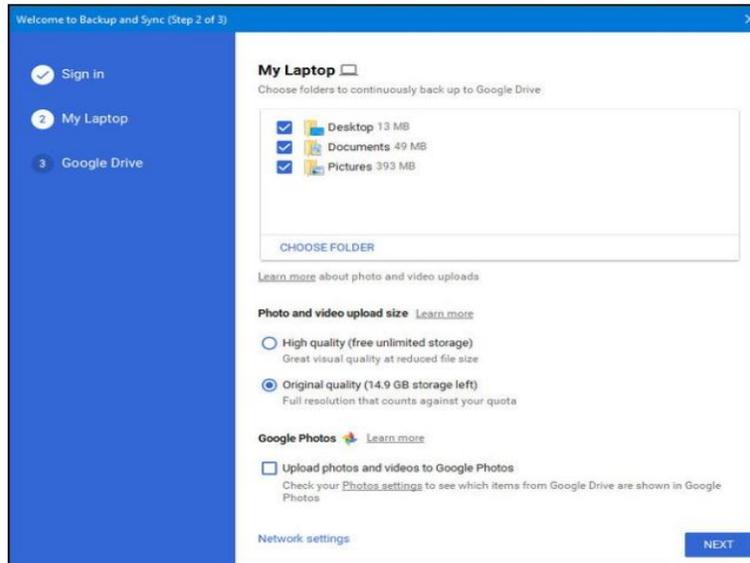


Figure 6 Google drive

Video conferencing:

Construction projects involve collaborating and communicating with several people from different sites operating in separate locations. Furthermore, whether it's collaborating on design and planning, reviewing and sourcing components from different suppliers, specifying changes, reviewing snagging lists or getting approval from clients, there are visual aspects to most communications in this industry. This company can leverage galore of benefits by implementing Google hangout video conference solution in our working model.

Real-time communication with site and team colleagues:

Each of our sites has a supervisor and inspector who monitor the ongoing work and progress. The site engineer can use the video conferencing system to connect with other colleagues remotely and discuss ways of taking the project forward. Scheduling site meetings at a time convenient for all parties can be a challenge, particularly with the time constraints involved in construction. With hangouts, the new generation of mobile video communication services providing high definition quality from any device, gathering remote workers together for meetings is a real possibility; this solution will also allow him to check the progress of the construction going on using the live video stream. By doing this, traveling and related cost will be reduced, which frees him for other important tasks

Instant plan share and training sessions:

Apart from monitoring our engineers will need to share the plans for the next phase of construction. Google hangout provides video collaboration solutions which enable disparate parties to view plans, 3D models and site progress and get instant feedback. The conference

system also provides features which the site engineers can use to raise the queries to ensure perfect understanding of the deliverables. Hangouts can also be used for training purposes where you may need to train the workers with concepts like how to use the machinery more effectively.

Enhanced updates for Owners and clients:

One of the most important jobs is to provide regular updates to the manager or owner and the clients. Hangout offers the digital medium with advanced facilities to share the daily reports and progress updates with charts and other graphics. By doing this you can showcase the 3D models. This type of presentation can give a clear view of the progress made and next phase expectation model.

Recruitment made easy:

This video conferencing solution will offer our company the opportunity to conduct remote interviews for instances where a staff is needed immediately at one of our sites in a distant location. Being able to speak face-to-face, without having to travel to meet potential subcontractors or employment candidates reduces costs. Having the ability to record and archive video interviews can be used as evidence in the event any future questions over skills claims or compliance issues. This will help with flexibility and convenience for both parties. Also the ability to judge response based on facial expressions and body language is important in projects where words alone don't quite convey what is meant.

All round accessibility:

These video conferencing solutions are platform and device independent. Thus, it can be used from anywhere, using any device. Hangouts works seamlessly with various devices like your tablet, laptops and smart phones and also allows users to use a dial-in phone number to join a meeting (audio-only) when out and about, if they don't have an internet connection, this feature is only found in g suite. This increases the accessibility. The site engineers, inspectors and site workers can use it remotely as when required.

This video conferencing solution come with many more features which offers benefits such as:

- Enhanced communication and collaboration
- improved productivity
- Time saver
- Reduced traveling
- Money saver
- Contribution in green environment

- Improved ROI



Figure 7 Video conference scenario on a construction site

Project management:

When you manage a lot of projects using the right tools could make all the difference. Google docs, sheets and forms will be used for employee work flow, project planning and a resources inventory database. With this, work-based collaboration is simplified. The lag time that exists with emailing documents to other employees is eliminated as communication is real-time and access to documents is available to everyone. Conversations are efficient as files share easily among allowed individuals. It is available for many file types such as documents; spreadsheets; presentations; drawings; web forms etc.

When employees work in remote areas, Google Docs lets you all work together on single documents at the same time. You can each also access the shared folder of files. Feedback and changes save instantly.

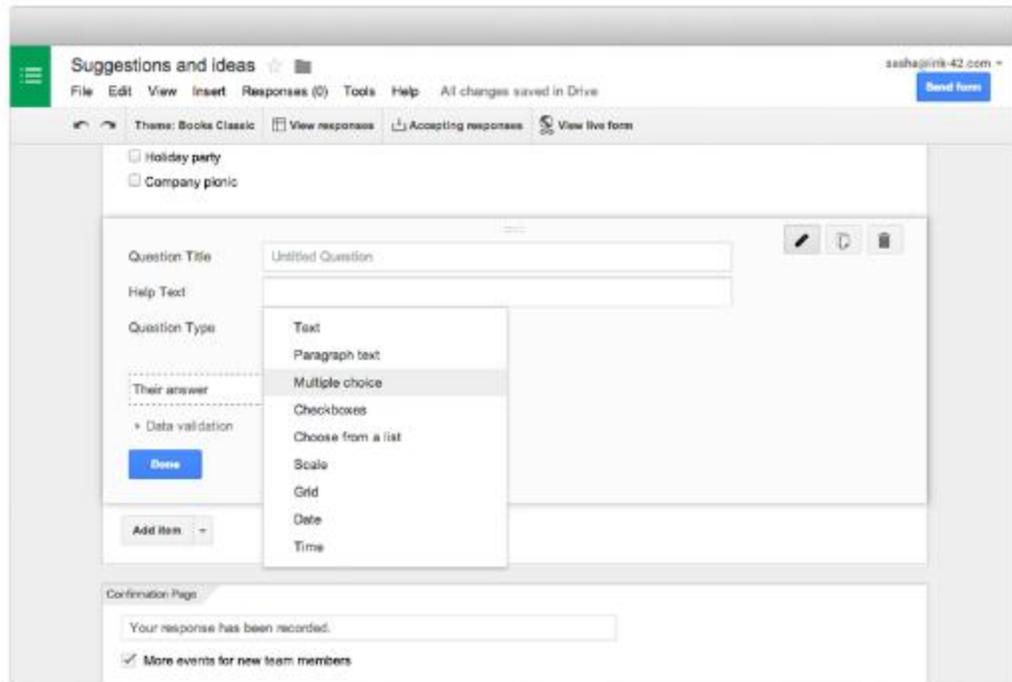


Figure 8 Google sheets

Once implementation of the Google g suite is completed, training will be carried out to every staff and contractor involved in any of our project. This training will help the personnel and other users to be able to maneuver the system properly.

FUTURE SOLUTIONS

Integrating augmented reality (AR) into Construction SME's

What is augmented reality?

Augmented reality (AR) is a live, direct or indirect, view of a physical, real world environment whose elements are augmented by computer-generated sensory input such as sound, video, graphics or GPS data. [10] A better definition of AR in relation to AEC will be a technology that allows you to superimpose computer-generated images created in CAD or building information modeling (BIM) software onto a user's view of the real world, which creates a composite or augmented view. [11]

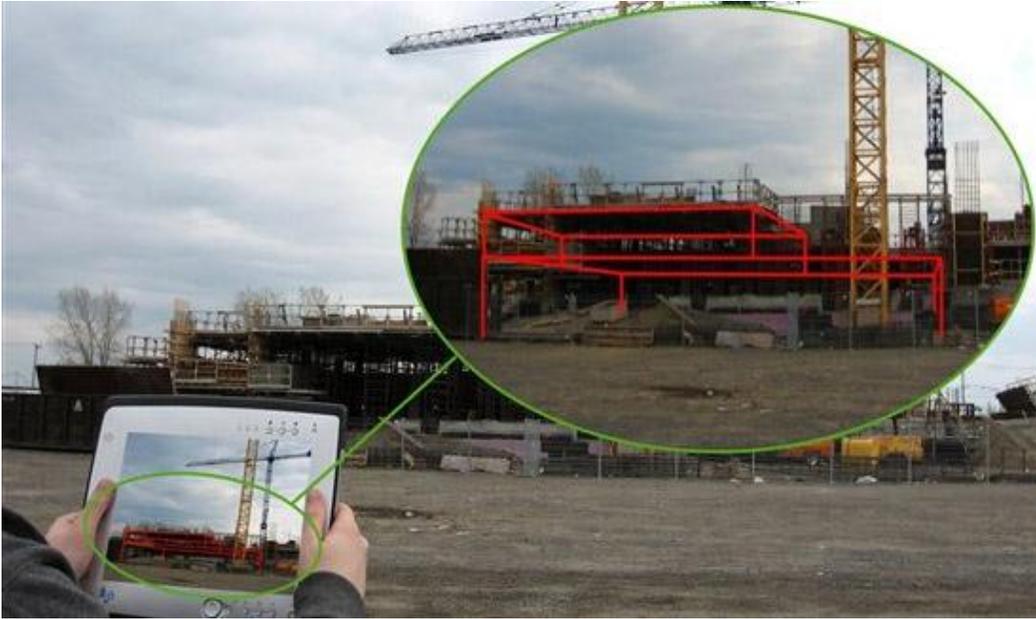


Figure 9 -Screen capture of data overlay gotten from a real world environment using a smart device

Looking at the technology components that form an AR system will help assess the impact it will have in the construction sector.

AR system components:

Location tracking: This is how the AR content is positioned relative to the physical real-world environment. Some common examples of tracking methods include GPS, Barcode, Image recognition, edge based tracking etc.

Visual rendering engine: This is how the AR content is generated.

Content management system: This is how the AR content is managed and delivered to the AR display.

AR Display: How the User interacts with AR content. Examples include tablet devices, smart phones and AR glasses.

Benefits of AR for Construction SME's:

1. It will help present designs better to clients/investors and give them an in-depth detailed view of what is to be expected from the project. They will be able to interact with their building and give feedback on the design before ground has been broken. This added dimension of visualization gives life-like insight into the design details which can't be achieved through a 2D image or even the current uses of 3D models.
2. It gives the architect or design engineer the idea of how the design will work in a real life environment. Architects use augmented reality to interact with their virtual models, making design scenarios much easier to manipulate rather than a physical model that has to be remodeled if any construction changes are needed.
3. By overlaying virtual data and images on to a physical space, potential flaws that may arise in complicated processes can be spotted early. Workers are able to see how a

construction schedule might be affected by potential problems and take measures to avoid them. This will improve the overall safety of the site.

4. AR's capacity to deliver cost savings and reduce the chances of a build falling behind schedule will lead to improved relationships between the company and investors.
5. The implementation of this technology will improve synergy between all parties involved within the process of the construction, for example the interior contractor can work hand in hand with the architect to see how and what furniture's will properly fit into a building.

CONCLUSION

Having delivered the aims of the report, the conclusion drawn from the above proposition shows that there are major advantages of deploying modern IT solution for SME's in the construction sector. Within this report several solutions were introduced for enhancing document sharing and communication in the context of a construction SME.

I introduced the three different cloud computing service models- SaaS, IaaS and PaaS. I also reviewed the four main types of clouds- Public, Private, community and hybrid clouds to find out which was best suited for my case study. I also looked at the possibility of integrating augmented reality and the benefits construction sme's stand to gain. Although this is still a relatively new technology that comes with a huge financial cost, it has the potential to change the way we approach projects and should be invested in the future.

I proposed the use of Google G suite to address the IT challenges faced by my company. The implementation of google g suite would allow the synchronization of project information and enable efficient and smooth completion of works. This seems like a huge step in the right direction for the company in allowing collaborative teams to easily access and modify shared models in the cloud without a need for additional hardware. I strongly believe that the problems of communication and badly coordinated documentation will be hugely reduced through the adoption of this cloud computing solutions. The pros from migrating to the cloud mostly out way the cons from my own company point of view as regarding flexibility to work from any location, cost and security.

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