The positive impacts offered by Healthcare Cloud and 3D Bioinformatics

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Abstract

Cloud Computing Business Framework (CCBF) is a framework for designing and implementation of Could Computing solutions. This paper focuses on how CCBF can help to address portability in Cloud Computing implementations in the Health domain, and NHS Bioinformatics in particular. These benefits of CCBF are illustrated using several case studies such as tumour modelling, brain imaging, insulin molecules and simulations for medical training. All projects and case studies show how adopting CCBF has assisted in the design and implementation of a Health Platform as a Service (HPaS), which has helped these projects collaborate and improve the quality of their research.

1. Introduction

Cloud Computing offers a variety of benefits including cost-saving, agility, efficiency, resource consolidation, business opportunities and green IT [2, 4, 5, 7, 8, 9]. While more organisations adopt Cloud, this brings technical and business challenges, in particular a need for a standard, or a framework to manage both operation management and IT services. To address increasing requirements from Industry and Academia, a structured framework to provide business needs, recommend for the best practices and which can be adapted to different domains and platforms is necessary. Our proposed framework is called the Cloud Computing Business Framework (CCBF). The objective is to help organisations achieve good Cloud design, deployment and services, and deliver solutions, recommendations and case studies to businesses. The CCBF is proposed to deal with four key areas:

- Classification of business models to offer Cloud-adopting organizations the right strategies and business cases.
- Offer a structured framework to review cloud business performance accurately.
- Deal with application portability from desktops to clouds and, later on, between clouds offered by different vendors.
- Provide linkage and relationship between different cloud research methodologies, and between IaaS, PaaS, SaaS and Business Models.

This paper focuses on the third area, Portability, and its case studies in Health domain.

2. Portability and CCBF Overview

Portability involves moving entire applications from desktops to clouds and between different Clouds in a way which is transparent to users so they may continue to work as if still using their familiar systems [1, 2]. The CCBF has helped Guy's and St Thomas NHS Trust (GSTT) and King's College London (KCL) to build and consolidate private cloud projects. With increasing research needs and user demands, private cloud needs to upgrade to PaaS to provide three different services. The first service is 3D Bioinformatics and details are presented in Section 4. The second service is Computational Statistics for researchers to write statistical applications and perform high performance calculations. The third service is the extended Cloud storage project that allows writing and improving applications and functionality. These three services have been successfully upgraded from IaaS to PaaS, and have satisfactory user feedback. The focus of this paper is about NHS Bioinformatics, and discusses solutions on offer and the positive impacts to research and IT services.

3. Development for Health Cloud

The CCBF has helped Health Community such as GSTT and KCL, to design, build and support private cloud for its research and IT services. Pilot private cloud projects in the NHS are to improve services and research activities in the local domains. Data sharing is only for authorised internal users, and prevention of data loss and disaster recovery service is in place. Security is highly important, and it includes the integrated solution with access control, enforced firewall, anonymisation, anti-viruses and anti-spam, encryption and decryption, prevention and detection technologies and network authentication.

The Health Cloud is actively used in the Breast Cancer project, and Breast cancer is the most common cancer in women and has a worldwide annual incidence of over 1 million cases [6]. There are thousands of data concerning about patients (medical records) and tumours (detailed descriptions and images, and its relations to the patients). Data growth is rapid and needs to be carefully used and protected. The work involves integrating software and cloud technologies from commercial vendors and in-house applications, thus ensuring a solid infrastructure and platform is available, scalable and robust. There are uses of third party applications to allow researchers to be able to access, view and edit any tumour images from trusted places. The Health Cloud has two projects and focuses: (i) NHS Infrastructure and (ii) NHS Bioinformatics. The NHS infrastructure provides automation, data sharing, backup, data recovery and analysis services. The NHS

Bioinformatics offers scientific visualisation and modelling of genes, proteins, DNA, tumour and brain images.

4. Bioinformatics

The NHS Bioinformatics started in September 2008 and completed in February 2011. It is an in-house solution focusing on scientific visualisation and modelling aiming to understand research analysis and improve existing services. The use of Cloud offers two distinct advantages:

(i) A PaaS for developers to simulate dynamic 3D modelling and visualisation for proteins, genes, molecules and medical imaging, where results can be instantaneous and data can be visualised, stored and shared securely.

(ii) Any complex modelling, such as growth of tumour and segmentation of brains, can be presented with the ease.

Each section is described as follows.

4.1 Tumour Modelling

Tumours develop as a result of abnormal and rapid growth of cells, and there are two types of tumours. The first type is benign tumours, which are harmless to human bodies. The second type is malignant tumours, which are malicious and should be removed and patients should be treated as soon as possible. Despite current technologies can take high-resolution pictures of tumours, it is extremely helpful for high performance Cloud resources to simulate the growth and formation of tumours, and this allows scientists and surgeons to diagnose possibilities of tumour growth and gain a better understanding about treatment [6].

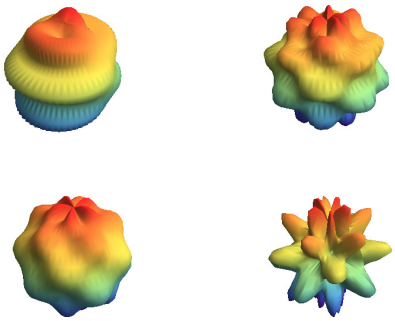

Figure 1: Selected figures in Tumour modelling

4.2 Medical Imaging

Medical imaging is widely adopted in Hospitals and medical institutes, and new ways to improve existing medical imaging services are regularly exploited. Bioinformatics Cloud platform allows computation and visualisation, and currently brain imaging can be used for demonstration. The aim is to study segmentation of brains, which divides the brain into ten major regions. The Cloud platform has these two functions: (i) it can highlight each region for ten different segments; and (ii) it can adjust intensity of segmentation to allow basic study of brain medicine. Figure 2 below shows selected brain imaging. Segmentation is an important aspect in brain study and it has two different functionalities. Firstly, it can highlight different areas in the cerebrum, where the different light intensity can highlight which particular areas. Secondly, segmentation can show different areas in the brain, including cerebellum, temporal lobe, mid-brain and so on. This allows medical students and instructors to understand the structure of human brain with the ease, but it also provides a platform to identity the right spot of the brain in a quick and efficient manner.

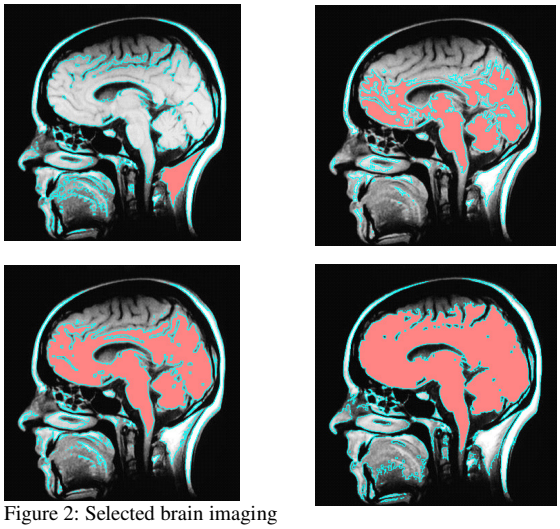

Figure 2: Selected brain imaging

4.3 Insulin Molecules

Insulin is a hormone central to regulating carbohydrate and fat metabolism in the body, and is important for type one diabetes treatment. Insulin has a molecular structure, and the study of its structure and formation of insulin help scientists to understand how to improve treatment more effectively, where Cloud offers a platform for simulations and modelling. Cutting-edge techniques are used for Health Cloud for 3D Visualisation and modelling.

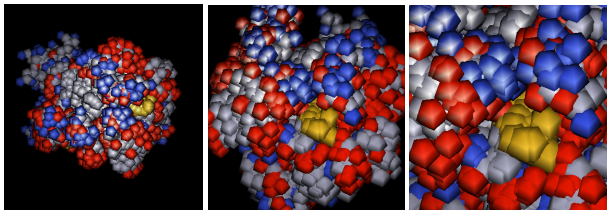

Figure 3: Investigation of insulin molecules on Cloud

This allows researchers to identify the areas in the molecule that they plan to study, and it allows 360 degrees rotation and zooming function, so that one particular area in the molecule can be magnified for different studies. Figure 3 shows the insulin molecule in original size and in zooms.

4.4 Simulations for medical training

3D simulations on Cloud are very useful for medical education and workshop, since explanations can be made easier and participants can understand better with the aid of visualisation. 3D simulations such as DNA modelling, Poyllotaxis Spirals and cleavage of embryos have been used for training, and have positive feedback and support.

5. Implication to Research and Education

Cloud Computing offers contributions to research and development, as complex simulations can be computed and modelled with the on-demand capabilities, elasticity and scalability that Cloud can provide. Genes, molecules and medical imaging can be modelled at a fast speed, where results can be computed and viewed in real-time. This is due to the establishment of PaaS to minimise the execution time, so that 3D simulation can be running right after the code development on Cloud.

NHS Bioinformatics also compares the performance improvements before and after introducing Cloud as an important ROI measurement, in which Chang et al. [3] demonstrate that 1.2% - 7.2% time reduction for code development is achieved, as well as their objective is clearly met and project delivery is straightforward with progressive improvements.

Different Health Cloud projects in Infrastructure, Bioinformatics, Statistics, HPC, Data Services and Security have worked together in an integrated environment to establish Health Platform as a Service (HPaas), which allows the following benefits:

- Different activities in private cloud can work together.
- The expertise in each area can be consolidated within the HPaaS.
- The outcome of one service can be the input to another.

Advantages of adopting HPaaS are as follows. Efficiency is always improving as the Cloud saves time and resources to repeat the same processes, which can be automated. This is important in case the systems and/or services break that automated virtualised environments can quickly provision to the original setting. 3D Bioinformatics enhances the level of research and simulations can help surgeons and medical staff to make the right decisions.

Chang et al. [4] also demonstrate Business Integration as a Service (BIaaS) that can further improve the process and integration of different activities in HPaaS.

6. Conclusion and Future Work

Cloud Portability has been designed, implemented and serviced at participating organisations to provide added values such as efficiency improvement and time reduction in code development and execution time. The use of 3D simulations of tumour, medical imaging and insulin have helped improving the quality of research analysis, as well as a better understanding in the structure and formation of these analyses. The use of 3D simulations helps medical education and workshop with positive support.

The HPaaS is a platform to enable different activities in Health Cloud to work together, so that expertise in one area can be consolidated. In addition, the outcome of one service can be used as the input of another, and future work will include the development of BIaaS in Health Cloud. The use of 3D simulations allows developers to compute results in real-time and data can be stored, visualised and shared securely. All complex life science modelling can be presented with the ease, so that it not only can promote a greater awareness of health and disease issue, but also improves the quality and standard of current research and development. The CCBF is useful and helping the Health Community to achieve good private cloud design, deployment and services while meeting their requirements and challenges.

7. References

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