



**UNIVERSITY OF
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INTEROPERABILITY IN CLOUD COMPUTING: AN
INNOVATIVE GOVERNANCE-BASED ARCHITECTURAL
MODEL

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PUBLICATIONS

The following is a list of my published conference papers and peer-reviewed journal articles that has contributed towards my thesis.

- Sutherland, S. (2013). Convergence of interoperability of cloud computing, service oriented architecture and enterprise architecture. International Journal of E-Entrepreneurship and Innovation (IJEI), 4(1), 43-51.
- Sutherland, S. (2013). Convergence of Cloud Computing, Service Oriented Architecture and Enterprise Architecture. In The Third International Conference on Digital Information Processing and Communications (pp. 493-500). The Society of Digital Information and Wireless Communication.
- Convergence of Interoperability of Cloud Computing (Mini Proposal)... - AISTI. www.aistic.org/cisti2013/oc13/modules/request.php?module.
.Convergence of Interoperability of Cloud Computing, Service Oriented Architecture and Enterprise Architecture.
- Sutherland, S., & Chetty, G. (2014). Migration to cloud computing: a sample survey based on a research in progress on the investigation of standards-based interoperability protocols for the convergence of cloud computing, service oriented architecture and enterprise architecture. Int. J. Inf. Process. Management, 5(1), 50-61.

- Sutherland, S. (2014). Secure APIs and protocols to connect enterprise applications to cloud services. In Proceedings of Informing Science & IT Education Conference (pp. 323-336).
- Paper ID: F3003 Paper Title: Investigation into Cloud Computing Interoperability: An Architectural Model. With heartiest congratulations I am pleased to inform you that based on the recommendations of the reviewers and the Technical Program Committees, your paper identified above has been accepted for publication and oral presentation by 2015 The 7th International Conference on Future Computer and Communication (ICFCC 2015) ICFCC 2015 conference received over 130 submissions from countries and regions so far, reviewed by international experts; the acceptance ratio is controlled below 35%. Your paper will be published in the Journal of Computers (JCP, ISSN 1796-203X) after registration. Herewith, the conference committee sincerely invites you to come to present your paper at ICFCC 2015 to be held on Singapore, May 20-22, 2015.
- Sutherland, S., & Chetty, G. (2016). Investigation into Interoperability in Cloud Computing: An Architectural Model. JCP, 11(2), 159-168.

Chapter review:

- Srinivasan, S. (Ed.). (2014). Security, trust, and regulatory aspects of cloud computing in business environments. IGI Global.

ABBREVIATIONS

API	application programming interfaces
CA	Computer Associates
CCIF	Cloud Computing Interoperability Forum
ENISA	European Network and Information Agency
ERS	enterprise register of services
ESB	enterprise services bus
FEA	Federal Enterprise Architecture
IaaS	infrastructure as a service
IAF	integrated architecture framework
ISO	International Standards Organisation
IS	information systems
ITIL	Information Technology Information Library
NIST	National Institute of Standards and Technology
OCCI	open cloud computing interface
OCSI	open cloud standards incubator
OEAF	Oracle Enterprise Architecture Framework
PaaS	platform as a Service
REST	representable state transferable
SaaS	software as a service
SLA	service level agreement
SOA	service oriented architecture
SOAP	simple object access protocol
SOCCA	service oriented cloud computing architecture
UML	universal modelling language
XML	extensible mark-up language

ABSTRACT

The significance of cloud interoperability has been highlighted both by industry and academia. Attempts to resolve the issue of interoperability in cloud services by developing open standards only partially eliminates the problem of seamless integration of various architectural components to connect enterprise systems to cloud services. Achieving interoperability requires rigorous analysis of existing enterprise architectures and working out the best fit to include architecture principles that will enable an impetus to the paradigm shift of cloud services.

Cloud computing solutions by cloud vendors have not been built with a focus on interoperability (Sheth, et al 2010). Furthermore, vendor solutions lock the customers in to unique vendor software data and software creation, thus creating vendor-locking situations for customers (McKendrick 2010). This is further accentuated by the battle of vendors, like Amazon, Google, and Salesforce, and is not conducive to moving to agreed standards for compatibility. The European Network and Information Agency (ENISA) recognise the vendor locking problem, but it will have to wait until international bodies such as the Cloud Computing Interoperability Forum (CCIF) and the Open Cloud Computing Interface (OCCI) deliver their research findings.

From the preliminary readings in this research area, the writer identified that there is no total interoperability among enterprise architecture, service oriented architecture (SOA) and cloud services. Further definitions of these three domains are available in

Chapter 3. The research further explored this gap via a questionnaire and established that interoperability in cloud computing was a key issue and sometimes prevented stakeholders from approving the implementation of cloud services. The responses from the questionnaire validated the need to establish standards-based interoperability models to provide much-needed connectivity to cloud services.

Based on the responses to the sample survey and the reviewed literature, this research developed a research framework as documented in Chapter 3 as a fundamental precursor to proposing a solution to the research gap.

Several research methodologies were evaluated to work out the best research methodology to develop a novel enterprise governance-based architectural interoperability in cloud computing. The novel model was achieved by leveraging design research methods. Denning (1997) defines design science as a problem-solving paradigm. March and Smith (2006) articulate four general outputs of a research design:

- constructs;
- models;
- methods; and
- instantiates.

This architectural model was validated via uses cases based on three implementation models. The use cases were further validated via systems analysis modelling tools underpinning universal modelling language (UML). The use case validation was further tested via a survey sent to selected academics and industry experts who were

either researching in the space of cloud interoperability or practising in the space of integration in the provision of cloud services

While Chapter 1 has articulated the broad contributions of this thesis, this research made specific contributions in the following areas:

- a governance-based architecture model;
- review of enterprise ICT architectures to include requesting platform services, including protocols such as Extensible Mark-up Language (XML), Web 2.0 protocols and open source connectors in the delivery of cloud computing services;
- review of enterprise ICT architectures to include cloud interoperability brokers such as API gateway and iPaaS integrators in the delivery of cloud computing services;
- common services to be deployed by enterprises;
- business efficiencies;
- other benefits to enterprises; and
- service level agreements.

A revisit of current industry practices in the deployment of cloud services and the interoperability issues in the provision of cloud services along with scanning of the academic literature since 2013 indicate the following:

- Academic literature has concentrated on highlighting the issue of interoperability while waiting on the standards bodies to articulate and

promulgate the standards required for a seamless integration of cloud services and enterprise systems.

- Industry literature provides many a solution on the interconnection of cloud services with SOA, but no generic solutions have appeared for the convergence of SOA, enterprise architecture and cloud services.
- While enterprises have concentrated on the prototype, pilots and the implementation of single vendor connections to cloud services to gain an in-depth understanding and requirements of their respective strategic planning, discussions with limited subject experts in practice indicate that the next steps will be the inclusion of an enterprise governance-based architectural model to include cloud services and its integration into mainstream enterprise computing.

The proposed model puts forth as an *enterprise governance-based architectural model* which includes a *requesting platform of services* component and a *cloud interoperability broker services* component that allows the convergence of the three domains: enterprise architecture, SOA and cloud services. Hence, this model caters and supports the interoperation between and among enterprise architecture, enterprise systems and cloud computing services.

Until further testing is carried out of use cases via proof of concept, it will be difficult to establish the cost of the provision of these services via this model as well as its technical and operational feasibility. Thus, this proposed architectural model also provides an opportunity for the research community to validate their respective

application use cases against this model and provide comments and feedback to the author.

A major contribution of this research is that while it commenced with the development of an innovative architectural model to solve the interoperability issues of the convergence of enterprise architecture, SOA and the cloud services in response to the gap identified in the research framework, its final output is a creation of a global solution for the enterprise systems to connect to cloud services via the inclusion of two key components, namely, the requesting services and cloud interoperability broker thus empowering enterprises to have governance over its interoperability issues.

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