

# **STUDY OF SELECT ISSUES IN CLOUD-BASED SERVICES SUPPLY CHAIN**

**SANJAY KUMAR PRASAD**



**DEPARTMENT OF MANAGEMENT STUDIES  
INDIAN INSTITUTE OF TECHNOLOGY DELHI**

**February 2018**

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**STUDY OF SELECT ISSUES IN  
CLOUD-BASED SERVICES SUPPLY CHAIN**

*by*

**Sanjay Kumar Prasad**

**Department of Management Studies**

*Submitted*

*in fulfillment of the requirements for the degree of Doctor of Philosophy*

*to the*



Indian Institute of Technology Delhi  
Hauz Khas, New Delhi – 110016

February 2018



*“One not knowing a land asks of one who knows it,  
he goes forward instructed by the knowing one.  
Such, indeed, is the blessing of instruction,  
one finds a path that leads him straight onward.”*

Rig Veda 10.32.7



*Dedicated to My Family*





# CERTIFICATE

This is to certify that the thesis titled “**Study of Select Issues in Cloud-Based Services Supply Chain**” being submitted by Mr. Sanjay Kumar Prasad (Entry No. 2011SMZ8432) to the Department of Management Studies, Indian Institute of Technology, Delhi, for the award of the degree of Doctor of Philosophy (Ph.D.) is a record of bona fide research work carried out by him. He has worked under my guidance and supervision, and has fulfilled the requirements for the submission of this thesis, which has attained the requisite standard for Ph.D. degree from the Indian Institute of Technology Delhi. The results presented in the thesis have not been submitted, in part or full, to any other University or Institute for the award of any degree or diploma.

**(Prof. Ravi Shankar)**

Research Supervisor  
Department of Management Studies  
Indian Institute of Technology Delhi  
Hauz Khas, New Delhi-110016



## **ACKNOWLEDGEMENTS**

First and foremost, I would like to express my deepest gratitude to my supervisor Prof. Ravi Shankar for the inspiration and guidance needed to complete this work. Without his rock-solid support and patience, this thesis would not have been possible. He gave me enough freedom to explore new horizons and always provided the gentle guiding hand.

I would like to thank my beloved parents, who have been my real inspiration and sowed the seeds of curiosity and perseverance in me, traits which proved to be essential in completing my doctoral program. Special thanks are owed to my wife Manisha and two lovely daughters (Saanvi and Nyasa), who sacrificed many weekends and holidays to enable me to work on the thesis. I am also thankful to my brother Sanjeev K Prasad. who inspired me to undertake the research journey.

Last, but not the least, I would like to thank my fellow researchers and academicians for their many helpful suggestions and for providing support as needed.

**Sanjay Kumar Prasad**



# ABSTRACT

Over the last few years, industrial-based economy is transforming rapidly to a services-based economy. Especially, cloud-based services sector has shown a tremendous growth underlining need for studying this sector in detail and applying supply chain principles (already proven in physical goods supply chain) to it.

This thesis investigates capacity coordination in cloud-based services supply chain. A model is developed to represent a global cloud-based services supply chain incorporating services specific factors like over-capacity cost and higher degree of substitution resulting in flexibility to meet unplanned demand. It provides discussion and application of various contracts in a two-stage single period services supply chain. It analyzes cloud-based services supply chain under various assumptions on demand profile and sensitivity (or lack thereof) to factors such as price, marketing and quality. Further, this problem is studied under various models of cooperation (or non-cooperation) and power. Additionally, some of widely used contracting mechanisms are studied and side-payment contract parameters are derived for stable equilibrium conditions.

Further, the research also studies the problem of surplus allocation in a coordinated supply chain. Especially, it focuses on the impact of bargaining powers of firms in supply chain coordination, and studies selected aspects of bargaining powers namely impatience, breakdown probability and outside options.

The thesis finds several key insights for the researchers and practitioners in this area around adverse impact of over-capacity cost on demand, positive effect of delivery team's exposure to market on contracting terms and better understanding of efficient frontiers for selected contracting mechanism.

Cloud computing offers "pay as you go" IT services to users world-wide. To enable this, resource provider host myriad applications from various domains, and there is a rising phenomenon of mega data centers. These data centers hosting cloud applications consume

huge amounts of electrical energy, contributing to high operational costs and carbon footprints. This thesis studies the problem of tactical resource allocation in cloud and develops a model to assign service requests to servers for maximizing time-sensitive customer utility.

Next, we analyze and study blockchain-based cloud services. We identify and analyze various critical success factors (CSFs) that can facilitate success of blockchain-based cloud services. Further, a framework for blockchain-based cloud services has been developed, wherein the hierarchical inter-relationships between CSFs have been identified. CSFs have been presented and interpreted using total interpretive structural modeling (TISM). Cross-impact matrix multiplication applied to classification analysis has been further employed to identify the driving power as well as dependence power of these CSFs.

The thesis derives multiple interesting insights and closed-form equations for potential application in services coordination and resource management. Further, a structural model for blockchain-based cloud services has been developed. An automated software agent can be built leveraging the closed-form equations developed in the thesis to help in areas such as (a) optimal capacity investment decision, b) devise coordinating contracts, and c) optimal profit splits in a cloud or e-commerce setting. Further, insights from this work can be leveraged by academia and practitioners in the cloud-based services supply chain.

## सार

पिछले कुछ वर्षों में औद्योगिक आधारित अर्थव्यवस्था एक सेवाओं आधारित अर्थव्यवस्था में तेजी से परिवर्तित हो रही है। विशेषकर, कलाउड-आधारित एस सेवा क्षेत्र ने इस क्षेत्र को विस्तार से अध्ययन करने और आपूर्ति श्रृंखला के सिद्धांतों (पहले से ही भौतिक वस्तुओं की आपूर्ति श्रृंखला में साबित) को लागू करने के लिए जरूरी विकास दिखाया है।

यह थीसिस कलाउड-आधारित सेवाएं आपूर्ति श्रृंखला में क्षमता समन्वय की जांच करता है। वैश्विक कलाउड-आधारित सेवाओं की आपूर्ति श्रृंखला का प्रतिनिधित्व करने के लिए एक मॉडल विकसित किया गया है, जिसमें सेवाओं की विशिष्ट कारकों को शामिल किया गया है; जैसे कि अधिक-क्षमता लागत और प्रतिस्थापन की उच्च डिग्री जिसके परिणामस्वरूप अनियोजित मांग को पूरा करने के लिए लचीलापन होता है। यह दो-चरण एकल अवधि सेवा आपूर्ति श्रृंखला में चर्चा और विभिन्न अनुबंधों के आवेदन प्रदान करता है। यह इस तरह के मूल्य, विपणन और गुणवत्ता जैसे कारकों से मांग प्रोफाइल और संवेदनशीलता (या अभाव?) पर विभिन्न धारणाओं के तहत कलाउड-आधारित सेवाओं की आपूर्ति श्रृंखला का विश्लेषण करती है। इसके अलावा इस समस्या का सहयोग (या असहयोग) और शक्ति के तहत विभिन्न मॉडलों का अध्ययन किया गया है। इसके अतिरिक्त व्यापक रूप से प्रयुक्त अनुबंध तंत्र का अध्ययन किया जाता है, और साइड-पेमेंट कॉन्ट्रैक्ट के तहत स्थिर संतुलन परिस्थितियों के लिए पैरामीटर प्राप्त होते हैं।

इसके अलावा यह अनुसंधान एक समन्वित आपूर्ति श्रृंखला में अधिशेष आवंटन की समस्या का भी अध्ययन करता है। विशेष रूप से यह आपूर्ति श्रृंखला समन्वय में फर्मों की सौदेबाजी की



शक्तियों के प्रभाव पर केंद्रित है, और सौदेबाज़ी शक्ति के चयनित पहलुओं जैसे अधीरता, टूटने की संभावना और बाहर के विकल्पों का अध्ययन करती है।

थीसिस इस क्षेत्र में शोधकर्ताओं और प्रबंधकों हेतु मांग, करार की शर्तों पर बाजार के लिए वितरण टीम के जोखिम के सकारात्मक प्रभाव और चयनित करार तंत्र के लिए कुशल सीमाओं की बेहतर समझ पर अधिक क्षमता लागत का प्रतिकूल प्रभाव सम्बंधित कई महत्वपूर्ण अंतर्दृष्टि पाता है।

क्लाउड कंप्यूटिंग विश्व भर में उपयोगकर्ताओं के लिए आईटी सेवाओं "पे अज यू गो" भुगतान के तहत उपलब्ध कराती है। इसे सक्षम करने के लिए संसाधन प्रदाता विभिन्न डोमेन से असंख्य अनुप्रयोगों को होस्ट करता है, और मेगा डेटा केंद्रों की एक बढ़ती हुई घटना है। ये डेटा केंद्रों की मेजबानी क्लाउड अनुप्रयोगों में बड़ी मात्रा में बिजली की खपत होती है, जो उच्च परिचालन लागतों और कार्बन पदचिह्नों में योगदान देता है। इस शोध क्लाउड में संसाधनों के आवंटन रणनीति की समस्या का अध्ययन करता है और समय के प्रति संवेदनशील ग्राहक उपयोगिता को अधिकतम करने के लिए सर्वर के लिए सेवा अनुरोध आवंटित करने के लिए एक मॉडल विकसित करता है ।

इसके उपरांत हम ब्लॉकचैन आधारित क्लाउड सेवाओं का विश्लेषण और अध्ययन करते हैं । हम विभिन्न महत्वपूर्ण सफलता कारकों (सीएसएफ) की पहचान और विश्लेषण करते हैं, जो ब्लॉकचैन आधारित क्लाउड सेवाओं की सफलता को प्राप्त कर सकते हैं। तत्पश्चात ब्लॉकचैन आधारित क्लाउड सेवाओं के लिए एक ढांचा तैयार किया गया है, जिसमें सीएसएफ के बीच वर्गीकृत पारस्परिक संबद्धता पहचाने गए हैं । सीएसएफ को कुल व्याख्यात्मक संरचनात्मक मॉडलिंग (टीआईएसएम) का प्रयोग करके प्रस्तुत किया गया है। आगे, इन सीएसएफ के ड्राइविंग

पावर के साथ-साथ निर्भरता शक्ति की पहचान के लिए वर्गीकरण विश्लेषण पर लागू क्रॉस-प्रभाव मैट्रिक्स गुणा नियोजित किया गया है।

थिसिस सेवाओं समन्वय और संसाधन प्रबंधन में संभावित आवेदन के लिए कई दिलचस्प अंतर्दृष्टि और पूर्ण-सूत्र समीकरणों में योगदान प्रदान करता है। इसके अलावा, ब्लॉकचैन आधारित क्लाउड सेवाओं के लिए एक संरचनात्मक मॉडल विकसित किया गया है। इस थिसिस में विकसित क्लोज्ड-फॉर्म समीकरणों, जैसे कि (ए) इष्टतम क्षमता निवेश निर्णय, बी) समन्वय अनुबन्ध विकसित करना, और सी) क्लाउड या ई-कॉमर्स में इष्टतम लाभ विभाजन व्यवस्था, का लाभ उठा कर एक स्वचालित सॉफ्टवेयर एजेंट निर्मित किया जा सकता है । इसके अलावा, क्लाउड-आधारित सेवाओं की आपूर्ति श्रृंखला में शिक्षकों और प्रैक्टिशनरों द्वारा इस काम की अंतर्दृष्टियों का फायदा लिया जा सकता है ।

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# ABBREVIATIONS

<b>AHP</b>	Analytic Hierarchy Process
<b>ANP</b>	Analytic Network Process
<b>AS</b>	Account Stackelberg
<b>B2C</b>	Business to Consumer
<b>CSF</b>	Critical Success Factor
<b>CG</b>	Cooperative Game
<b>CPU</b>	Central Processing Unit
<b>DS</b>	Delivery Stackelberg
<b>ECU</b>	Elastic Compute Unit
<b>FMCG</b>	Fast Moving Consumer Goods
<b>GB</b>	Gigabyte
<b>GDP</b>	Gross Domestic Profit
<b>IaaS</b>	Infrastructure as a Service
<b>IT</b>	Information Technology
<b>LT</b>	Lead Time
<b>JIT</b>	Just in Time
<b>MICMAC</b>	Matriced' Impacts Croise's Multiplication Appliquée a UN Classement (Impact Matrix Cross- Reference Multiplication Applied to a Classification)
<b>OLS</b>	Ordinary Least Squares
<b>PaaS</b>	Platform as a Service

<b>RAS</b>	Resource Allocation Strategies
<b>SaaS</b>	Software as a Service
<b>SCOR</b>	Supply Chain Operations Reference
<b>SLA</b>	Service Level Agreement
<b>SCM</b>	Supply Chain Management
<b>SSC</b>	Services Supply Chain
<b>SSCM</b>	Services Supply Chain Management
<b>SSCPM</b>	Services Supply Chain Performance Management
<b>TISM</b>	Total Interpreting Structural Modeling
<b>VCN</b>	Value Creation Network
<b>VM</b>	Virtual Machine
<b>VN</b>	Vertical Nash