

**QUERY PERFORMANCE OF CORBA TRADING OBJECT
SERVICE USING LDAP AS BACKEND STORAGE**

FARKHANA BINTI MUCHTAR

UNIVERSITI UTARA MALAYSIA

2007

QA
76.64
E2242



**JABATAN HAL EHWAL AKADEMIK
(DEPARTMENT OF ACADEMIC AFFAIRS)
UNIVERSITI UTARA MALAYSIA**

**PERAKUAN KERJA/TESIS
(Certification of Thesis Work)**

Kami, yang bertandatangan, memperakukan bahawa
(We, the undersigned, certify that)

FARKHANA MUCHTAR

calon untuk Ijazah
(candidate for the degree of)

SARJANA SAINS (TEKNOLOGI MAKLUMAT)

telah mengemukakan tesis/disertasinya yang bertajuk
(has presented his/her thesis work of the following title)

**QUERY PERFORMANCE OF CORBA TRADING OBJECT SERVICE
USING LDAP AS BACKEND STORAGE**

seperti yang tercatat di muka surat tajuk dan kulit tesis/disertasi
(as it appears on the title page and front cover of thesis work)

bahawa tesis/disertasi tersebut boleh diterima dari segi bentuk serta kandungan, dan liputan bidang ilmu yang memuaskan, sebagaimana yang ditunjukkan oleh calon dalam ujian lisan yang diadakan pada : **23 Mei 2007**
(that the thesis/dissertation is acceptable in form and content, and that a satisfactory knowledge of the field covered by the thesis was demonstrated by the candidate through an oral examination held on

Pengerusi Viva (Chairman for Viva)	: Prof. Madya Dr. Norshuhada Shiratuddin	Tandatangan: (Signature)	
Pemeriksa Luar (External Examiner)	: Prof. Madya Dr. Hamidah Ibrahim	Tandatangan: (Signature)	
Pemeriksa Dalaman (Internal Examiner)	: Prof. Madya Nazib Nordin	Tandatangan: (Signature)	
Penyelia Utama (Principal Supervisor)	: Prof. Madya Dr. Zulkhairi Md. Dahalin	Tandatangan: (Signature)	
Dekan, Fakulti Teknologi Maklumat (Dean, Faculty of Information Technology)	: Prof. Madya Dr. Suhaidi Hassan	Tandatangan: (Signature)	

Tarikh
(Date) : **23 MEI 2007**

**Query Performance of CORBA Trading Object Service
using LDAP as Backend Storage**

**This thesis is presented to the graduate school
in fulfillment of the requirement
for Master of Science (Information Technology)
Universiti Utara Malaysia**

By

Farkhana Binti Muchtar

Permission to Use

In presenting this thesis in the fulfillment of the requirement for a Master of Science in Information Technology degree from Universiti Utara Malaysia, I agree that the University Library may make it freely available for inspection. I further agree that permission for copying this thesis in any manner, in whole or in part, for scholarly purposes may be granted by my supervisor or, in their absence, by the Dean of the Graduate School. It is understood that any copying or publication or use of this thesis or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to Universiti Utara Malaysia for any scholarly use which may be made of any material from my thesis.

Request for permission to copy or make other use of material in this thesis, in whole or in part, should be addressed to:

Director of Graduate School

Academic Affairs Department

Universiti Utara Malaysia

06010 UUM Sintok

Kedah Darul Aman

Abstrak (Bahasa Melayu)

Penyelidikan ini merupakan satu inisiatif ke arah meningkatkan prestasi *trading service* di dalam persekitaran CORBA bagi membolehkan tindak balas daripada *trader server* menjadi lebih pantas apabila sesuatu permintaan dari pengguna dilakukan. Berdasarkan pernyataan daripada spesifikasi *trading service* yang diisukan oleh OMG dan juga dari penyelidikan-penyelidikan yang lepas, pemilihan storan belakang tabir mempengaruhi prestasi *trading service*. Oleh kerana itu, penumpuan diberikan terhadap pemilihan penyelesaian berdasarkan storan sokongan yang sesuai untuk *trader server* dalam meningkatkan operasi carian dalam *trading service*.

Storan yang optimum pada operasi pembacaan data dipilih sebagai penyelesaian yang digunakan dalam penyelidikan ini, kerana ia dapat membenarkan proses carian dan capaian dipertingkatkan dalam *trading service* apabila proses permohonan berlaku. Fakta tersebut telah dibuktikan dalam penyelidikan ini dan storan yang dipilih sebagai penyelesaian ialah LDAP.

Di dalam tesis ini mengandungi kupasan terhadap kajian keupayaan LDAP dalam meningkatkan prestasi operasi permohonan dalam *trading service* di mana pengukuran prestasi dilakukan untuk membezakan keputusan prestasi daripada *trading service* yang menggunakan LDAP sebagai storan sokongan dan *trading service* yang menggunakan pangkalan data biasa sebagai storan sokongan. Berdasarkan keputusan eksperimen yang dijalankan, didapati bahawa *trading service* yang menggunakan LDAP sebagai storan sokongan mempunyai prestasi yang lebih baik berbanding *trading service* yang menggunakan pangkalan data biasa sebagai storan sokongan. Keputusan yang diperolehi membuktikan bahawa wujud peningkatan prestasi pada *trading service* apabila menggunakan LDAP sebagai storan sokongan berbanding penggunaan pangkalan data biasa sebagai storan sokongan.

Abstract (English)

This research is an initiative towards increasing the performance of trading service in a CORBA environment so that the trader server can provide a fast response when a query is performed. Based on the statement in the trading service specification issued by OMG and past research, the selection of backend storage for the trader server influences the performance of the trading service. Thus, an emphasis on the selection of appropriate solutions is focused on the most suitable backend storage to be used by the trader server in order to improve the query operation in the trading service.

Read-optimized storage is the chosen criteria of backend storage for this research as, ultimately, it allows the searching and retrieving process to be improved in the trading service during the query operation. This fact is proven in this research, and the storage chosen as the suggested solution is LDAP.

This thesis examines the capability of LDAP in improving the performance of query operation in the trading service in which a performance measurement is conducted to differentiate the performance result obtained from the trading service which uses LDAP as its backend storage, and the trading service that uses relational database as its backend storage. Based on the experiments conducted, we find that the trading service using LDAP shows a better performance as compared to the trading service with the relational database. From the results, it has been further proven that there is an increase in the performance during the query operation in the trading service that uses LDAP as its backend storage.

Acknowledgements

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

Praise to the Almighty Allah who has granted me the permission to complete this study despite all odds. Here, I would like to extend my sincere gratitude and appreciation to:

- Dean of FTM, which also acts as my supervisor, Associate Professor Dr. Zulkhairi Md Dahalin for the advices, guidance and time spent on discussions.
- All friends in the Postgraduate Lab for the support, encouragement and happiness they have given during the period of my study in UUM.
- Universiti Utara Malaysia for the facilities and resources provided.

Dedications

I am forever thankful and in debt to my beloved mother, who have stood beside me in mind, body and spirit as I took on the challenges and obstacles of this research. Her encouragement has helped me not only to overcome but also to persevere and excel. To my brother and sister, your constant encouragement kept me afloat amidst the storm. I am forever thankful to all my family members, for believing in me, and for giving me faith to fight through struggles.

I would like to dedicate this small effort of mine to my family members who lovingly encouraged and supported me throughout this research:

- *My mother, Mrs. Aliwiyah Shaikh Salim*
- *My brother, Mr. Faisal Bawaze'er Muchtar*
- *My sister, Mrs. Fairuz Bawaze'er Muchtar*

Thank you so much...

Farkhana Bawaze'er Muchtar

Universiti Utara Malaysia, 2007

Table of Contents

Permission to Use	ii
Abstrak (Bahasa Melayu)	iii
Abstract (English)	iv
Acknowledgements	v
Dedications	vi
Table of Contents	vii
List of Figures	x
List of Tables	xi
List of Appendices	xii
List of Abbreviations	xiii
Chapter 1 Introduction to Research	1
1.0 Background	1
1.1 Problem Statement	2
1.2 Justification of the Proposed Solution.....	5
1.3 Research Objectives.....	6
1.4 Significance of the Study	7
1.5 Research Scope	8
1.5.1 Type of Trader Server and Properties	8
1.5.2 Performance Analysis Scope	9
1.6 Definition	10
1.7 Thesis Outline	12
Chapter 2 Literature Review	13
2.0 Introduction.....	13
2.1 Trading Service	13
2.1.1 Basic Role of Trading Service	14
2.1.2 CORBA Trading Service	15
2.1.3 The Importance of Query Operation in Trading Service	26
2.1.4 Prior Work on Backend Storage and Performance of Trading Service.....	28

2.2	LDAP Directory Service as the Solution	31
2.2.1	Why Focus on LDAP, Not Other Storage.....	31
2.2.2	Related Work on LDAP's Read Optimize Criteria.....	32
2.2.3	Related Work on Performance Evaluation of LDAP's Read Operation.....	33
2.2.4	LDAP Directory Storage.....	36
2.3	Integration Issue between Trading Service and LDAP	43
2.3.1	CORBA Persistent State Service	44
2.4	Performance Measurement Analysis of Trading Service.....	48
2.4.1	Performance Test Metrics of Trading Service	48
2.5	Summary	50
Chapter 3	Research Methodology	51
3.0	Introduction.....	51
3.1	Design Science Research	51
3.2	Design Research Method Used in This Study.....	52
3.2.1	Awareness of Problem	53
3.2.2	Suggestion of Solution	54
3.2.3	Development	54
3.2.4	Evaluation	55
3.2.5	Conclusion	56
3.3	Summary	56
Chapter 4	Design and Implementation	57
4.0	Introduction.....	57
4.1	System Design and Development Planning	58
4.2	Tools and Applications in the Development Process.....	59
4.2.1	OpenORB.....	60
4.2.2	Architecture of OpenORB Trading Service.....	60
4.2.3	Architecture of OpenORB Persistent State Service	62
4.2.4	Integration between OpenORB Trading Service and OpenORB Persistent State Service	64
4.3	System Development	66
4.3.1	Trader Server Development.....	66
4.3.2	Trader Console Development	78

4.4	Summary	82
Chapter 5	Result and Analysis	83
5.1	Introduction	83
5.2	Experiment Approach and Result Analysis	83
5.2.1	Experiment Approach	83
5.2.2	Result Analysis	85
5.3	Result Finding	87
5.3.1	Number of Service Offers in Storage vs. Query Response Time.....	87
5.3.2	Number of Offers Returned vs. Query Response Time	90
5.3.3	Number of Properties vs. Query Response Time.....	93
5.3.4	Number of Inheritance Nest vs. Query Response Time.....	97
5.4	Overall Conclusion	100
5.5	Summary	100
Chapter 6	Conclusion and Recommendations.....	102
6.0	Introduction	102
6.1	Research Objective Examined	102
6.2	Contribution of the Study.....	105
6.3	Limitation and Future Work.....	109
6.3.1	Implementation Improvement.....	109
6.3.2	Experiment Improvement	110
6.3.3	Extension to Scope of Study	111
6.3.4	Extension to Trader Model	111
6.3.5	Investigate Capabilities of SQLite Database.....	112
6.4	Summary	112
	References	114
	Appendices	121

List of Figures

No.	Title	Page
1.1	: Scope of Research Base on Type of Trader	9
2.1	: CORBA Trading Service Interaction	16
2.2	: Property Strength	18
2.3	: How Query Parameters Affect Offers Gathered	21
2.4	: Trading Service Architecture	22
2.5	: Performance Result of LDAP Read and Write Operations	33
2.6	: Read and Write Latency in Directory Server Loads	34
2.7	: Read and Write Throughput in Different Directory Server Loads.....	35
2.8	: Example of a Directory Tree.....	37
2.9	: Example of a Directory Entry Showing Attributes Types and Values.....	37
2.10	: DIT Structure in LDAP with DN and RDN of current Entry	38
2.11	: Searching by Search Base and Search Scope.....	40
2.12	: Persistent State Service Interface in CORBA Object Implementation	45
2.13	: PSS Object Implementation for Server Object	46
3.1	: The Design Research Approach.....	53
3.2	: Conceptual Model for the Study	54
4.1	: Architecture of CtosuL and CtosuD.....	58
4.2	: OpenORB Trading Service Architecture	61
4.3	: Communication between OOTS and OOPSS	64
4.4	: PSDL in OpenORB Trading Service Development.....	65
4.5	: Pseudo Code for dn String Generate Process.....	75
4.6	: Pseudo Code for Attribute Null Method	75
4.7	: Registered Oid for CtosuL's OpenLDAP Schema.....	77
4.8	: Adding <i>ctosul.schema</i> into <i>slapd.conf</i>	78
4.9	: Trader Console.....	79
4.10	: Trader Console that Show Service Offer Information at Information Space.....	80
4.11	: Experiment Management Menu.....	80
4.12	: Popup Window to Manage Experiment Process for Query Operation.....	81
4.13	: Pop up Window Showing a List of Query Result	81
5.1	: Experiment Process Diagram	84
5.2	: Graph of Number of Offers in Storage vs. Query Response Time	89
5.3	: Graph of Number of Service Offers Returned vs. Query Response Time (with 100 Offers in Storage).....	92
5.4	: Graph of Number of Service Offers Returned vs. Query Response Time (with 200 Offers in Storage).....	92
5.5	: Graph of Number of Service Offers Returned vs. Query Response Time (with 300 Offers in Storage).....	93
5.6	: Graph of Number of Properties vs. Query Response Time (with 1 Constraint)	96
5.7	: Graph of Number of Properties vs. Query Response Time (with 3 Constraints).....	96
5.8	: Graph of Number of Properties vs. Query Response Time (with 5 Constraints).....	97
5.9	: Graph of Number of Inheritance Nest vs. Query Response Time.....	100
6.1	: PMO in Integrated Simulation Framework.....	111

List of Tables

No.	Title	Page
2.1	: Type of Trading Service.....	24
2.2	: Search Filter Operators.....	41
2.3	: Boolean Operators.....	41
2.4	: Search Filter Examples.....	42
2.5	: PSS Object Hierarchy.....	46
4.1	: Tool Used in This Study.....	59
4.2	: The Difference Observed in OOTS Bootstrap Command Before and After Modification Process.....	68
4.3	: List of Element in ServiceType.....	69
4.4	: List of Element in ServiceTypeRepository	70
4.5	: List of Element in Offer	70
4.6	: List of Elements in OfferRepository	71
5.1	: Result from Experiment's Number of Offers in Storage	88
5.2	: Descriptive Statistic Result for Experiment's Number of Offers in Storage	89
5.3	: Result from Experiment's Number of Offer Returned.....	90
5.4	: Descriptive Statistic Result for Experiment's Number of Offer Returned.....	91
5.5	: Result from Experiment's Number of Properties/Constraints	94
5.6	: Descriptive Statistic Result for Experiment's Number of Properties/Constrain	95
5.7	: Result from Experiment's Number of Inheritance Nest.....	98
5.8	: Descriptive Statistic Result for Experiment's Number of Inheritance Nest.....	98

List of Appendices

No.	Title	Page
A	: Configuration in pss.xml for CtosuD	122
B	: Storage Home and Storage Object	123
C	: Syntax Modification for CtosuD and CtosuL.....	126
D	: Configuration in pss.xml for CtosuL.....	128
E	: Trading Service Information in OpenLDAP.....	129
F	: Screen Shot of CtosuL and CtosuD Trader Console.....	130
G	: Number of Offers vs. Query Response Time.....	135
H	: Number of Offer Returned vs. Query Response Time.....	137
I	: Number of Properties vs. Query Response Time.....	141
J	: Number of Inheritance Nest vs. Query Response Time.....	146

List of Abbreviations

API	: Application Programming Interface
BOA	: Basic Object Adapter
CN	: Common Name
CORBA	: Common Object Request Broker Architecture
DB	: DataBase
DBM	: DataBase Management
DIT	: Directory Information Tree
DN	: Distinguished Name
DNS	: Domain Name Service
DOK-Trader	: Distributed Object Kernel-Trader
DOG	: Distributed Object Group
DRYAD	: DiRectorY ADventure
GIOP	: General Inter-ORB Protocol
GUI	: Graphical User Interface
IANA	: Internet Assigned Numbers Authority
ID	: Identifier
IDE	: Interactive Development Environments
IDL	: Interface Definition Language
IIOP	: Internet Inter-ORB Protocol
IO	: Input Output
ITU	: International Telecommunication Union
JDBC	: Java DataBase Connectivity
JDK	: Java Development Kit
JNDI	: Java Naming and Directory Interface
JVM	: Java Virtual Machine
LDAP	: Lightweight Directory Access Protocol
LDSS	: Lightweight Distributed Directory Server
NIS	: Network Information Service
O	: Organizational
ODP	: Open Distributed Processing
OID	: Object Identifier
OMG	: Object Management Group
OMG PSS	: Object Management Group Persistent State Service
OMG TOS	: Object Management Group Trading Object Service
OOPSS	: OpenORB Persistent State Service
OOTOS	: OpenORB Trading Object Service
OpenLDAP	: Open Lightweight Directory Access Protocol
ORB	: Object Request Broker
OS	: Operating System
OSI	: Open Systems Interconnection
OOTSS	: OpenORB Transaction Service
OU	: Organizational Unit
PID	: Persistent Identifier
PMO	: Performance Measurement Object

POA : Portable Object Adapter
PSDL : Persistent State Definition Language
PSS : Persistent State Service
RDBMS : Relational DataBase Management System
RDN : Relative Distinguished Name
RFC : Request For Comments
RTF : Revision Task Force
SDK : Software Development Kit
SLAPD : Stand-alone LDAP Daemon
SN : Surname
SQL : Sequence Query Language
TCP/IP : Transfer Control Protocol/Internet Protocol
TOS : Trading Object Service
UID : User ID
UUID : Unique User ID
X.500 : ITU-T Recommendation X.500
W3C : World Wide Web Consortium

Chapter 1

Introduction to Research

1.0 Background

CORBA or Common Object Request Broker Architecture is a middleware standard for a language-independent object model and specification in a distributed application development environment. CORBA is the solution for the heterogeneity of distributed systems where complexity exists during integration of each component in the distributed system (Vinoski, 2000; Vinoski, 1997).

In common with other distributed system concepts, the key word for the role of CORBA is 'sharing', which includes data, information, analysis, functions, etc. All objects which are shared in the CORBA distributed system environment are known as object resources (Vinoski, 2000; Vinoski, 1997). Here, the issue of how each component in a distributed system acquires the required object resource arises since the location of the required object resource must first be known before it can be shared with each component.

CORBA has two services that offer the facilities of object resource reference; namely, the CORBA Naming Service and the CORBA Trading Service. The CORBA Naming Service functions as the information provider's 'white pages' in which the object reference is referred based on the simple name during the lookup process (Emmerich, 2002; Emmerich, 2000).

In contrast to the CORBA Naming Service, the CORBA Trading Service is more efficient than the CORBA Naming Service since each component – or "clients" – will not always know the names for the components' identity they require, however, clients will always know the criteria of the components that they are looking for (Emmerich, 2002; Emmerich 2000).

The contents of
the thesis is for
internal user
only

References

- Arkills, B. (2003). *LDAP Directories Explained - An Introduction and Analysis*. Boston: Manning Publications.
- Arnott, D.R. (2006). Cognitive Biases and Decision Support Systems Development: A Design Science Approach. *Information Systems Journal*, 16, 55-78.
- Atsan, K. (2003). ELIAC (Easy LDAP Interface for Authentication and Confidentiality) - A Custom Protocol Design for Secure LDAP Access. *Türkiye'de İnternet Konferansları - INET-TR'03*, Askeri Müze, Harbiye Kültür Sitesi, İstanbul.
- Bachvarov, C. (2006). *Security Architectures for Sharing of Distributed Resources in Community Based Systems*. Master Thesis. Department of Electrical Engineering, Faculty of Electrical Engineering, Mathematics and Computer Science, Delft University of Technology, Netherlands.
- Bearman, M. (1994). ODP-Trader. In J.D. Meer, B. Mahr and S. Storp (Eds.), *Proceedings of the IFIP Tc6/Wg6.1 International Conference on Open Distributed Processing II: Vol. C-20* (pp. 37-51), IFIP Transaction. Berlin, Germany: Elsevier Science Publishers BV.
- Benc, I., Plavec, F., & Srblijic, S. (2003). Designing Scalable Storage System for Application Oriented Middleware – MidArc. In *Proceeding of the 7th World Multi-Conference on Systemics, Cybernetics and Informatics - SCI'03: Vol. 3 Communication, Network and Control Systems, Technologies and Applications*, (pp. 241-245). Orlando, Florida, USA: IEEE Computer Society.
- Biemer, M., & Hampe, J. F. (2005). A Mobile Medical Monitoring System: Concept, Design and Deployment. In *Proceedings of 4th International Conference on Mobile Business - ICMB'05*, 464-471. Los Alamitos, CA, USA: IEEE Computer Society.
- Boeg, J., Madsen, T.S., Persson, J., & Steinson, F. (2006). *Managing Risks in Geographically Distributed Software Projects*. Technical Report d604a, Institute of Computer Science, University of Aalborg, Denmark.
- Brose, G., Vogel, A., & Duddy, K. (2001). *Java Programming with CORBA* (3rd ed.). New York, NY: John Wiley & Sons, Inc.
- Carlson, W.L., & Thorne, B. (1997). *Applied Statistical Methods*. New Jersey: Prentice Hall.
- Chee, Y. C. (1998). *Trading Object Service in Distributed Systems*. Master Thesis, School of Computer Science and Software Engineering, Monash University, Australia.
- Chidambaram, A. (2002). *Implementation and Validation of Network Policy Services*. Master Thesis, Faculty of Computer Engineering, North Carolina State University, Raleigh, North Carolina.

- Coakes, S.J. (2005). *SPSS: Analysis without Anguish Version 12.0 for Windows*. Milton, Queensland: John Wiley & Sons.
- Craske, G., Tari, Z., & Kumar, K.R. (1999). DOK-Trader: A CORBA Persistent Trader with Query Routing Facilities. In *Proceedings of the International Symposium on Distributed Objects and Applications - DOA '99* (pp. 230-240). Washington DC, USA: IEEE Computer Society.
- Davis, J.M. (2001). *An Ambient Computing System*. Master Thesis, Department of Electrical Engineering and Computer Science, University of Kansas, Lawrence, Kansas.
- Desprez, F., Quinson, M., & Suter, F. (2001). Dynamic Performance Forecasting for Network-Enabled Servers in a Heterogeneous Environment. In H.R. Arabnia (Ed.), *Proceedings of the International Conference on Parallel and Distributed Processing Techniques and Applications - PDPTA '01: Vol. 3* (pp. 1421-1427). Las Vegas: CSREA Press.
- Donley, C. (2003). *LDAP Programming, Management and Integration*. Greenwich, CT: Manning Publications.
- Donnelly, M. (2000). Introduction to LDAP. *The Journal of the System Administrators Guild of Australia*, 6(2), 15-21.
- Ebner, H. (2006). *Collaborilla - An Enhancement to the Conzilla Concept Browser for Enabling Collaboration*. Master Thesis, School of Computer Science and Communication, Royal Institute of Technology, Department of Computer and Systems Sciences, Royal Institute of Technology, Stockholm University, Sweden.
- Emmerich, W. (2000). *Engineering Distributed Object*. Chichester, UK: John-Wiley & Sons.
- Emmerich, W. (2002). OMG/CORBA: An Object-Oriented Middleware. In: J.J. Marciniak (Ed.). *Encyclopedia of Software Engineering* (pp. 902-907). UK: John Wiley & Sons.
- Erickson, J. (2005). *Bridging the Gap between Development and Use - Support of Tailorability in Software Evolution*. Licentiate Thesis, Department of Interaction and System Design, School of Engineering, Blekinge Institute of Technology, Sweden.
- Ey, C.R. (2000). *Managing Content with Directory Servers*. Diploma Thesis, Department Business Information Systems, Karlsruhe University of Applied Sciences, Germany.
- Fan, B., Kumar, K., & Tari, Z. (1998). An Efficient Trader using Attribute Clustering Technique in Distributed Object Systems. In *Proceedings of the International Conference on Parallel and Distributed Processing Technique and Applications - PDPTA '98*. Las Vegas, Nevada, USA: CSREA Press.
- Fink, J. (2003). *User Modeling Servers: Requirements, Design and Implementation*. PhD Thesis, Department of Mathematics and Computer Science, University of Essen, Germany.
- Frølund, S., & Koistinen, J. (1998). Quality-of-Service-Aware Distributed Object Systems. *Distributed System Engineering Journal*, 5 (4), 69-84.

- Gavirneni, S. (2003). *Directory Enabled Distributed Packet Filtration System: A Scalable and High Performance Security Architecture*. Master Thesis, Department of Electrical Engineering and Computer Science, University of Kansas, USA.
- Geisler, R. (1999). *A Remote Monitor System for Distributed Application using the Soft Real-Time Scheduler*. Master Thesis, Department of Computer Science, University of Illinois at Urbana-Champaign, Germany.
- Goodchild, A. (1996). An Overview of Catalog Design Problems in Resource Discovery. *Internet Research: Electronic Networking Applications and Policy*, 6(1), 33-43.
- Gopinath, A., Nimmagadda, S., Liyanaarachchi, C., & Niehaus, D. (2001). *Performance Measurement of CORBA End Systems*. Technical Report ITTC-FY99-TR-1412001, University of Kansas, USA.
- Gregg, D.G., Kulkarni, U.R., & Vinzé, A.S. (2001). Understanding the Philosophical Underpinnings of Software Engineering Research in Information Systems. *Information Systems Frontiers*, 3(2), 169-183.
- Herlekar, A., Deopujari, A., Ramamritham, K., Gopale, S., & Shukla, S. (2002). enTrans: A System for Flexible Consistency Maintenance in Directory Applications. In *Proceedings of 28th International Conference on Very Large Data Bases - VLDB '00* (pp. 1095-1098). Hong Kong, China: Morgan Kaufmann.
- Hevner, A.R., March, S.T., Park, J., & Ram, S. (2004). Design Science in Information Systems Research. *MIS Quarterly*, 28(1), 75-105.
- Howes, T.A. (1995). *The Lightweight Directory Access Protocol: X.500 Lite*. Technical Report TR-95-8, Center for Information Technology Integration, University of Michigan, USA.
- Howes, T.A., Smith, M.C., & Good, G.S. (2003). *Understanding and Deploying LDAP Directory Services* (2nd ed.). USA: Macmillan Technical Publishing.
- IONA CORBA Trader Service Guide (2003),
<http://www.iona.com/support/docs/e2a/asp/5.0/corba/trader.pdf>
- Jaakkola, H. (2000). *Directory Enabled Networks: A Study about Security and Performance*. Master Thesis, Kungliga Tekniska högskolan University, Stockholm, Sweden.
- Jae, J.Y., & Soo, D.K. (1999). SMARTS: A Smart CORBA Trader Service. In *Proceedings of the 6th Asia Pacific Software Engineering Conference - ASPEC '99* (pp. 166-173). Washington DC, USA: IEEE Computer Society.
- Johner, H., Melot, M., Strandén, H., & Widhiasta, P. (1999). *LDAP Implementation Cookbook*. Number SG24-6163-00 in IBM Redbooks. IBM Corporation, International Technical Support Organization, USA.
- Jampen, T. (2002). *Authentication, Authorization and Resource Reservation for Distributed Laboratories*. Diploma Thesis, Institute for Computer Science and Applied.
- Kearns, D. (2004). *The Administrator Shortcut Guide to User Management and Provisioning* [online]. USA: Real Time Publishers.

- Kebbal, D., & Bernard, G. (2001). Component Search Service and Deployment of Distributed Applications. In *Proceedings of the 3rd International Symposium on Distributed Objects and Applications - DOA'01* (pp. 125). Washington, DC, USA: IEEE Computer Society.
- Kim, J.-B., Strecker, S., Kersten, G.E., & Law, K.P. (2005). *Component-Based Software Protocol Approach*. InterNeg Working Paper, No. INR02/05, InterNeg Group, John Molson School of Business, Concordia University, Canada.
- Klasen, N. (2001). *Directory Services for Linux, in Comparison with Novell NDS and Microsoft Active Directory*. Master Thesis, Department of Computer Science, Rheinisch-Westf' A Lische Technische Hochschule University, Aachen, German.
- Kleindienst, J., Plášil, F., & Tůma, P. (1995). Implementing CORBA Persistence Service. Technical Report TR117, Department of Software Engineering, Charles University Prague, Czech Republic.
- Kolos-Mazuryk, L., Poulisse, G.-J., & Eck, P.V. (2005). Requirements Engineering for Pervasive Services. In *Proceedings of the 2nd Workshop on Building Software for Pervasive Computing at the Object-Oriented Programming, Systems, Languages and Applications - OOPSLA '05*. Netherlands: Handboek Telematica Toepassingen.
- Kotinurmi, P. (2005). Towards more Intelligent Business-to-Business Integration with Semantic Web Service Technologies. In *Proceedings of the 1st CIMRU-DERI-HP Research Seminar - CDH'05* (pp. 33-35). Galway, Ireland: Deri Technical Report.
- Kutvonen, L. (1998). *Trading Services in Open Distributed Environments*. PhD Thesis, Department of Computer Science, University of Helsinki, Finland.
- Le, N.-T. (2003). *User Management in Distributed Systems*. Master Thesis, Fachbereich Informatik, Universität Hamburg, Germany.
- Loshin, P. (2000). *Big Book of Lightweight Directory Access Protocol (LDAP)*. San Francisco, CA, USA: Morgan Kaufmann.
- Mangnes, B. (2005). *The Use of Levenshtein Distance in Computer Forensics*. Master Thesis, Department of Computer Science and Media Technology, Gjøvik University College, Gjøvik, Norway.
- March, S.T., & Smith, G.F. (1995). Design and Natural Science Research on Information Technology. *Decision Support System*, 15(4), 251-266.
- Marshall, B. (2004). LDAP Theory and Management. Tutorial presented at the System Administrators Guild of Australia Conference (SAGE'04), Hobart Tasmania, Australia. <http://quark.humbug.org.au/publications/ldap/ldap-theory.pdf>
- Marvie, R., Merle, P., Geib, J., & Leblanc, S. (2001a). Type-Safe Trading Proxies using TORBA. In *Proceedings of the 5th International Symposium on Autonomous Decentralized Systems - ISAD'01* (pp. 303). Washington, DC, USA: IEEE Computer Society.

- Marvie, R., Merle, P., Geib, J., & Leblanc, S. (2001b). TORBA: Trading Contracts for CORBA. In *Proceedings of the 6th USENIX Conference on Object-Oriented Technologies and Systems - COOTS'01* (pp. 1-14). San Antonio, Texas, USA: USENIX.
- Mohammad, A.S. (2005). *A Subscription Management System (SMS) in Mobile Internet Services (MISER)*. Master Thesis, Stockholm University, Sweden.
- Mowbray, T.J., & Zahari, R. (1995). *The Essential CORBA: System Integration Using Distributed Objects*. Canada: John Wiley & Sons, Inc.
- Nunamaker, J., Chen, M., & Purdin, T. (1991). System Development in Information Systems Research. *Journal of Management Information Systems*, 7(3), 89 – 106.
- ODP (1998). Trading Function Specification. ISO/IEC 13235-1:1998.
- OMG (2000). *Trading Object Service Specification, Version 1.0*. OMG Technical Document Number formal/2000-06-27.
- OMG (2002). *Persistent State Service Specification, Version 2.0*. OMG Technical Document Number formal/2002-09-06.
- OMG (2004). *The Common Object Request Broker Architecture and Specification, Version 3.0.3*. OMG Technical Document Number formal/2004-03-01.
- Orlikowski, W.J., & Iacono, C.S. (2001). Research Commentary: Desperately Seeking the "IT" in IT Research - A Call to Theorizing the IT artifact. *Information Systems Research*, 12(2), 121-134.
- Oxford English Dictionary (1989). Oxford, UK: Oxford University Press.
- Pluta, D. (2004). *User Management using LDAP*. Yearly CMS Essays, Site CMS, Fachhochschule Augsburg. University of Applied Science Augsburg, Germany.
- Puder, A., & Geihs, K. (1996). System Support for Knowledge-Based Trading in Open Service Markets. In *Proceedings of the 7th Workshop on ACM SIGOPS European Workshop - EW: Systems Support for Worldwide Applications* (pp. 289-296). New York, USA: ACM Press.
- Purao, S. (2002). *Design Research in the Technology of Information Systems: Truth or Dare*. GSU Department of CIS Working Paper, Atlanta.
- Richman, A., & Hoang, D. (1995). Accomplishing Distributed Traders utilising the X.500 Directory. *Proceedings of the 2nd IEEE Malaysia International Conference on Communications - MICC'95*, Malaysia.
- Scheir, P., & Graz, K.-C. (2006). Associative Retrieval of Resources for Work-Integrated Learning: Integrating Domain Knowledge with Content-Based Similarities. In *Proceedings of the 1st Doctoral Consortium in European Conference on Technology Enhanced Learning - EC-TEL'06* (pp. 72-81). Crete, Greece: Springer-Verlag.

- Schmitt, B. (2002). Impact and Potential of User Profiles Used for Distributed Query Processing-Based on Literature Services. In A.B. Chaudhri, R. Unland, C. Djeraba and W. Lindner (Eds.), *Proceedings of the Xmlm, Mdde and YRWS on XML-Based Data Management and Multimedia Engineering-Revised Papers*; Vol. 2490, Lecture Notes in Computer Science (pp. 555-565). London: Springer-Verlag.
- Senders, V.L. (1985). *Measurement and Statistic*. New York: Oxford University Press.
- Sgouros, N.M. (1993). *Representing Physical and Design Knowledge in Innovative Design*. PhD Thesis, Northwestern University, Evanston, Illinois.
- Siegel, J. (2000). *CORBA 3: Fundamentals and Programming*. New York, USA: John Wiley & Sons.
- Simon, H.A. (1996). *The Sciences of the Artificial* (3rd ed.). Cambridge, Massachusetts, USA: MIT Press.
- Steen, H., & Yang, C. (2001). *Integrating ABB Aspect Directory with Microsoft Active Directory*. Master Thesis, Mälardalens Högskola University, Sweden.
- Steinder, M., & Zielinski, K. (1997). Some Performance Aspect of Trader Service Implementations. *Proceeding of 13th Annual ACM SIGPLAN Conference on Object-Oriented Program, System and Language Application - OOPSLA '97*, Atlanta, USA.
- Steinemann, M.-A. (2005). *Distributed Architectures for Laboratory-Based E-Learning*. PhD Thesis, Institute for Computer Science and Applied Mathematics, University of Bern, Switzerland.
- Strohmaier, M.B. (2005). *B-KIDE: A Framework and a Tool for Business Process Oriented Knowledge*. PhD Thesis, Institute for Knowledge Management and Knowledge Visualization, Graz University of Technology, Austria.
- Tari, Z., & Bukhres, O. (2001). *Fundamentals of Distributed Object Systems: The CORBA Perspective*. Y. Z. Albert (Ed). USA: John Wiley & Sons, Inc.
- Tari, Z., & Craske, G. (2000). A Query Propagation Approach to Improve CORBA Trading Service Scalability. In *Proceedings of the 20th International Conference on Distributed Computing Systems - ICDCS'00* (pp. 504-51). Washington DC, USA: IEEE Computer Society.
- Thornton E.J., Mundy, D.P., & Chadwick, D.W. (2003). A Comparative Performance Analysis of Seven LDAP Directories. *Proceedings of Terena Networking Conference Conference - TNC'03*, Zagreb, Croatia.
- Tůma, P. (1997). *Persistence in CORBA*. PhD Thesis, Department of Software Engineering, Faculty of Mathematics and Physics, Charles University, Malostranské nám, Praha, Czech Republic, Prague.
- Tůma, P., & Buble, A. (2002). Overview of the CORBA Performance. *Proceedings of the 2002 EurOpen CZ Conference*, Znojmo, Czech Republic.

- Tokmakoff, A.A. (1998). *Modelling, Analysis and Prototyping of the ODP Trader using Coloured Petri Nets and Java*. PhD Thesis, Telecommunications Systems Engineering Centre, Institute for Telecommunications Research, University of South Australia, Australia.
- University of Michigan (2000). Lightweight Directory Access Protocol – Clients. University of Michigan. 13 September 2000. <http://www.umich.edu/~dirsvcs/ldap/ldclients.html>
- Vähäaho, M., Silfver, E., Haataja, J.-P., Kutvonen, L., & Alanko, T. (2001). *Pilarcos Demonstration Prototype - Design and Performance*. Technical Report C-2001-64, Department of Computer Science, University of Helsinki, Finland.
- Vaishnavi, V., & Kuechler, W. (2004). Design Research in Information Systems. ISWorld Web Site, <http://www.isworld.org/Researchdesign/drisISworld.htm>
- Vinoski, S. (1997). CORBA: Integrating Diverse Applications within Distributed Heterogeneous Environments. *IEEE Communications Magazine*, 35(2), 46-55.
- Vinoski, S. (2000). Introduction to CORBA. In *Proceedings of the 22nd International Conference on Software Engineering - ICSE'00*. New York: ACM Press.
- Wang, X., Schulzrinne, H., Kandlur, D., & Verma, D. (2000). Measurement and Analysis of LDAP Performance. *SIGMETRICS Performance Evaluation*, 28(1), 156-165.
- Weerd, I. (2005). *WEM: A Design Method for CMS-Based Web Implementations*. Technical Report UU-CS-2005-043, Institute of Information and Computing Sciences, Utrecht University, Utrecht, Netherlands.
- Wilcox, M. (1999). *Implementing LDAP*. Birmingham: Wrox Press.
- Wolisz, A., & Tschammer, V. (1993). Performance Aspects of Trading in Open Distributed Systems. *Computer Communications*, 16(5), 277-287.
- Yeong, W., Howes, T. & Kille, S. (1995). Lightweight Directory Access Protocol. <http://www.ietf.org/rfc/rfc1777.txt?number=1777>
- Yin, S.L. (2004). *Open Standards Migration of the Storage of Healthcare Demographic Information*. Master Thesis, University College London, London, UK.
- Zdun, U. (2005). Semantic Lookup in Service-Oriented Architectures. In M. Matera and S. Comai (Eds.), *Proceedings of Workshops in Connection with the 4th International Conference on Web Engineering Advanced Web Applications - ICWE'04* (pp. 124-135). Princeton: Rinton Press.
- Zimmerli, S., Steinemann, M., & Braun, T. (2003). Resource Management Portal for Laboratories using Real Devices on the Internet. *SIGCOMM Computing Communication Review*, 33(3), 145-151.