UNIVERSITI PUTRA MALAYSIA

POLICY-BASED DYNAMIC PROXY FRAMEWORK: AN APPLICATION LEVEL INFRASTRUCTURE FOR ACTIVE SERVICE CREATION AND CONTENTS DELIVERY

CHOONG KHONG NENG

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By

CHOONG KHONG NENG

Thesis Submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Doctor of Philosophy

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Specially Dedicated To All I Love

My Father
Choong Set Ching

My Mother
Yap Moi Lan

My Wife
Yee Yoke Chek

My Brother and Sister
Choong Khong Wei
Choong Khong Ying

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Chairman: **Professor Borhanuddin Mohd. Ali, Ph.D.**

Faculty: **Engineering**

This thesis focuses on the dynamic proxy framework named the Chek Proxy Framework (CPF). The main objectives are to scale the existing Internet architecture by conserving the backbone bandwidth, reducing server loads, and improving the overall networking system performance, particularly the client receiving rate. These were achieved by deploying application-level proxy services within the network, to accelerate and customise the delivery of contents.

The CPF is based on the 3-tier distributed computing architecture with the client and server residing at the ends of the respective networks. A dynamically appointed middle-tier system, the Dynamic Application Proxy Server (DAPS) is created on-demand and resides at the client-side network based on the designed clustering policy. The uniqueness of CPF lies on the use of voluntary client machines, instead of static and dedicated machines to host DAPS services created at runtime. This is

done by appointing selected clients (as proxy) that have already downloaded, or are downloading contents, to turn around and serve the contents to other clients within the same network segment governed by the adopted clustering policy, thereby relieving the server and network from redundant loads. Contents can be of both static and dynamic nature such as web pages and video streams. DAPS services include protocol conversion, message filtering and re-routing, transcoding, and caching.

Efforts have been made on implementing a prototype system and conducting simulation studies, based on different clustering policies. On the implementation aspect, attention was paid on defining the CPF architecture, its system components, operation modes and setup protocol, Chek Application Deployment System (CADS), Chek Application Service Template (CAST) and a Generic Object Transport (GOT). Simulations focus on evaluating two proposed proxy selection algorithms and on the performance gains of using CPF for networks of hierarchical topology.

The proposed framework opens avenues for building more complex services and applications such as customisable and reliable content dissemination, efficient collaborative system and congestion management. It is expected that, in the future, the application layer infrastructure approach will serve an important role for large-scale contents delivery in the Internet.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Doktor Falsafah

KERANGKA PROKSI DINAMIK MENGIKUT DASAR: SATU INFRASTRUKTUR LAPISAN APLIKASI UNTUK PEMBENTUKAN SERVIS AKTIF DAN PENGHANTARAN KANDUNGAN INTERNET

By

CHOONG KHONG NENG

Mac 2003

Pengerusi: **Profesor Borhanuddin Mohd. Ali, Ph.D.**

Faculti: **Kejuruteraan**

Tumpuan tesis ini adalah di atas satu kerangka proksi yang bernama Chek Proxy Framework (CPF). Objektif utama CPF adalah untuk mengabadikan lebar jalur tulang belakang rangkaian, mengurangkan beban pelayan dan meningkatkan prestasi rangkaian secara menyeluruh, terutamanya kadar penerimaan pelanggan. Objektif tersebut boleh dicapai dengan meletak-aturkan perkhidmatan proksi lapisan aplikasi di dalam rangkaian, untuk memecutkan penghantaran kandungan.

CPF adalah berdasarkan kepada senibina komputing teragih 3-peringkat, di mana kedua-dua pelangan and pelayan berada di hujung rangkaian masing-masing. Satu lagi sistem peringkat tengah, yang diberi name Dynamic Application Proxy Server (DAPS) dan dilantik secara dinamik dan mengikut permintaan, tinggal di rangkaian sebelah-pelanggan berasaskan kepada dasar pengelompokan yang ditentukan. Keunikan CPF adalah disebabkan oleh penggunaan komputer pelanggan yang

sukarela, bukannya komputer yang statik dan dedikasi, untuk menghoskan perkhidmatan-perkhidamtan DAPS yang tercipta sewaktu program berjalan. Ini dapat dilakukan dengan melantik pelanggan terpilih (sebagai proksi) yang telah atau sedang memuat-turunkan kandungan, untuk melayan pelanggan-pelanggan lain di segmen rangkaian yang sama, mengikuti dasar pengelompokan yang ditetapkan. Justeru itu, kaedah ini dapat menyenangkan pelayan dan rangkaian dari beban berganda. Perkhidmatan DAPS merangkumi penukaran protokol, penurasan dan pelaluan-semula mesej, transkodan dan caching.

Usaha dilakukan ke atas perlaksanaan prototaip dan simulasi yang berpandukan kepada dasar-dasar pengelompokan yang berlainan. Dari segi perlaksanaan, perhatian telah diberikan untuk mendefinisi senibina, ragam operasi dan protokol penyediaan CPF. Sistem Perletakan Atur Aplikasi CPF (CADS), Template Servis Aplikasi CPF (CAST) dan Pengangkut Objek Umum (GOT). Simulasi menjalankan penilaian terhadap dua jenis algoritma pemilihan proksi dan kepada gandaan pertunjukan melalui penggunaan CPF di rangkaian yang bertopologi hairaki.

Kerangkakerja CPF yang dicadangkan membuka ruang untuk pembinaan perkhidmatan-perkhidmatan yang lebih kompleks dan aplikasi-aplikasi seperti penyebaran kandungan yang boleh dipercayai dan diandalkan, sistem kolaboratif dan pengurusan kesesakan. Adalah dipercayai bahawa di masa akan datang, kaedah infrastruktur lapisan aplikasi akan memainkan peranan yang penting dalam penghantaran kandungan secara besar-besaran di Internet.

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AC	User-Aware Conservative
ACC	Active Congestion Control
ACL	Access Control List
AG	User-Aware Greedy
ALAN	Application Level Active Network
ALF	Application Level Framing
ALMI	Application Level Multicast Infrastructure
AMM	Application Management Module
AMnet	Active Multicasting Network
AN	Active Network
ARM	Active Reliable Multicast
AS	Autonomous Systems
BGP	Border Gateway Protocol
BTP	Banana Tree Protocol
CADS	CPF Application Deployment System
CAN	Content Addressable Network
CASS	CPF Application Supporting Service
CAST	CPF Application Service Template
CDF	Cumulative Density Function
CDN	Content Delivery Network
CIDR	Classless InterDomain Routing
CM	Client Module

CNP	Caching Neighborhood Protocol
COS	Cluster Operating Systems
CPF	Chek Proxy Framework
CSCW	Computer Supported Cooperative Work
DAPS	Dynamic Application Proxy Server
DES	Data Encryption Standard
DMM	Decision Making Module
DVMRP	Distance Vector Multicast Routing Protocol
E2E	End-to-End
GOT	Generic Object Transport
GRCD	Grass-Roots Content Distribution
GUI	Graphical User Interface
HDy	Hard Dynamic
HOB	Heavy ObjectBasket
HTTP	Hyper Text Transfer Protocol
ICP	Internet Cache Protocol
ISP	Internet Service Provider
JNI	Java Native Interface
JNLP	Java Network Launching Protocol
JWS	Java Web Start
LB	Load Balancer
LOB	Light ObjectBasket
MARCH	Mobile Aware Server Architecture

MAS	Mobile Agent System
MBone	Multicast Backbone
MMM	Metric Management Module
MMT	Mesh based Multicast
NAM	Network Awareness Module
NAT	Network Address Translation
NC	NAM-Client
NOS	Node Operating Systems
NS	NAM-Server
NTP	Network Time Protocol
P2P	Peer-to-Peer
PDA	Personal Digital Assistant
PGM	Pragmatic General Multicast
PPS	Packets Per Second
QCIF	Quarter Common Intermediate Format
RMX	Reliable Multicast Proxy
RPC	Reverse Proxy Caching
RTP	Real Time Transport Protocol
RTSP	Real Time Streaming Protocol
SAN	Storage Area Network
SDP	Secure Dynamic Proxy
SDy	Soft Dynamic
SM	Server Module

SNS	Scalable Network Services
SPAND	Shared Passive Network Performance Discovery
SRM	Scalable Reliable Multicast
TPS	Transparent Proxy Signaling
TTL	Time-To-Live
UC	User-Unaware Conservative
UG	User-Unaware Greedy
VPN	Virtual Private Network
WAP	Wireless Access Protocol

CHAPTER 1

INTRODUCTION

One of the main challenges to design a cost-effective network service is to maximise the number of clients that can be served, while minimising the workload of both the server and network backbone. These two conflicting requirements become more challenging given approximately 70% of today's Internet traffics are of dynamic nature (e.g. multimedia contents, personalised information and transactions) [1], which deemed to utilise more server and network resources, than the static contents (such as texts and pictures). This urges for better optimisation techniques to scale and improve the performance of the existing Internet infrastructure.

Internet optimisation techniques could be generally divided into either the network or application layer solution. Here, the network layer refers to the lowest 4 layers of the OSI reference model. Examples of optimisation techniques at these layers include upgrading or replacement of physical equipments (e.g. from cable circuit to fiber circuit), the use of different MAC protocols, Active Network (AN) [2], and the Transparent Proxy Signaling [3]. Examples of the application layer optimisation include the conventional cache proxy server, Content Delivery Network (CDN) [4, 5], Conductor [6] and the recent Peer-to-Peer (P2P) communication approach [7].

While the network-layer solution gains the merit of being transparent to higher communication layers, it is regarded less flexible and programmability as far as the support of application semantics are concerned [6, 8, 9]. On the contrary, working at the application layer allows the complexity associated with the large-scale broadcasting mechanisms such as MBone [10], be shifted from the routing layer to the application layer, renders them more manageable and programmable. Such migration also causes the issues of receivers' heterogeneity and application characteristics to be more tractable. The contents requested can be adaptively modified to suit the needs and attributes of the receivers. Moreover, customised application templates could be built (and also be made reusable) to tailor the requirements of the application, and leverage seamlessly on the existing TCP/IP layers. Deriving solutions at the application layer further avoids possible pitfalls and demerits, in terms of security, safety, deployment, and in some cases the performance, which were restricting the wide acceptance of network layer solutions [5, 8, 11, 12].

This thesis proposes an application level dynamic proxy solution to deal with the growing Internet, by deploying mobile code called the Dynamic Application Proxy Server (DAPS), into the network to customise and streamline the Internet service delivery. The framework discussed in this thesis is called the Chek Proxy Framework[1] (CPF). CPF exploits the application-level programmability to craft the DAPS with intelligence to execute server-delegated active services, such as protocol conversion, application-oriented message routing and contents transcoding. Unlike other proxy-

[1] The framework is named after the author's wife. The letter "C" in the word Chek also implies the meaning the Customisable and Collaborative, which are the key features of the framework.