A SEAMLESS PRODUCER MOBILITY MANAGEMENT MODEL FOR NAMED DATA NETWORKS

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Abstrak

Rangkaian Data Bernama (NDN) ialah senibina Rangkaian Berorientasikan Maklumat (ICN) yang direka untuk menyokong mobiliti sumber kandungan. Walaupun ia berkesan dalam mengendalikan mobiliti pengguna melalui penempatan cache kandungan, mobiliti pengeluar masih menjadi cabaran. Apabila pengeluar berpindah lokasi, penghala NDN masih mengarahkan permintaan ke lokasi asal, menyebabkan kehilangan paket Interest, kos isyarat yang tinggi, dan peningkatan kependaman peralihan. Masalah ini menjejaskan prestasi rangkaian dan kadar penghantaran data, sekali gus mendedahkan jurang dalam pengurusan mobiliti NDN. Kajian ini meneroka penyelesaian yang berkesan untuk meningkatkan mobiliti pengeluar, memastikan penghantaran kandungan yang lancar dan dioptimumkan dalam persekitaran rangkaian yang dinamik. Oleh itu, kajian ini bertujuan untuk mencadangkan Model Pengurusan Mobiliti Pengeluar (PMMM) untuk menangani cabaran mobiliti pengeluar yang berkaitan dan menyediakan laluan yang optimum. PMMM menggabungkan paket pengurusan mobiliti, termasuk Paket Pemberitahuan Mobiliti (MNP) dan Paket Kemaskini Mobiliti (MUP), dan mengubah suai proses penghantaran standard untuk menyokong paket pengurusan mobiliti ini dengan berkesan. MNP digunakan untuk memaklumkan rangkaian dan pengguna tentang mobiliti pengeluar, membantu mengurangkan kehilangan paket berlebihan dan kos isyarat yang tinggi. Sementara itu, MUP mengemaskini lokasi pengeluar dalam rangkaian, memaklumkan pengguna tentang ketersediaan pengeluar, dan mewujudkan laluan komunikasi yang optimum. Siri eksperimen mengesahkan bahawa PMMM meningkatkan prestasi rangkaian dengan mengurangkan kependaman peralihan, kos isyarat, dan kehilangan paket, serta meningkatkan pengoptimuman laluan dan kadar penghantaran data. Berbanding dengan IBM, PMSS, dan KITE, PMMM mengurangkan kependaman peralihan sehingga 24%, memastikan peralihan yang lebih lancar apabila pengeluar berpindah lokasi. Ia juga mengurangkan kos isyarat sehingga 31%, sekali gus mengurangkan beban rangkaian. Selain itu, pengoptimuman laluan meningkat sebanyak 25%, membolehkan penghantaran data yang lebih cekap. Kehilangan paket berkurang sebanyak 44% berbanding KITE dan 32% berbanding PMSS, memastikan penghantaran data yang lebih boleh dipercayai. Akhirnya, PMMM meningkatkan kadar penghantaran data sebanyak 17% berbanding KITE dan 12% berbanding PMSS, memperkukuh kestabilan rangkaian. Penemuan ini membuktikan bahawa PMMM berkesan dalam menangani cabaran mobiliti dalam NDN. Peningkatan ketara ini menyerlahkan potensi besar PMMM untuk penerapan masa depan, terutamanya dalam konteks teknologi termaju seperti Internet of Things (IoT), Internet of Medical Things (IoMT), dan rangkaian mudah alih generasi keenam (6G).

Kata Kunci: Rangkaian berpusatkan maklumat, Pemodelan analitik, serahan, Paket pengurusan mobiliti.

Abstract

Named Data Networking (NDN) is an Information-Centric Networking (ICN) architecture designed to support content source mobility. While it efficiently handles consumer mobility through content caching, producer mobility remains a challenge. When a producer relocates, NDN routers still direct requests to the original location, causing Interest packet loss, high signalling overhead, and increased handoff latency. These issues degrade network performance and throughput, highlighting a gap in NDN's mobility management. This study explores efficient solutions to enhance producer mobility, ensuring seamless and optimized content delivery in dynamic networks. Therefore, this research aims to propose a Producer Mobility Management Model (PMMM) to handles the associated producer mobility challenges and provides the optimal path. The PMMM incorporates mobility management packets, including the Mobility Notification Packet (MNP) and the Mobility Update Packet (MUP), and modifies standard forwarding processes to support these mobility management packets effectively. The MNP is used to inform the network and consumers about producer mobility, helping to reduce excessive packet loss and high signalling costs. Meanwhile, the MUP updates the producer's location within the network, notifies consumers of the producer's availability, and establishes an optimal communication path. A series of experiments confirm that PMMM improves network performance by reducing handoff latency, signalling costs, and packet loss, while enhancing path optimization and throughput. Compared to IBM, PMSS, and KITE, PMMM reduces handoff latency by up to 24%, ensuring smoother transitions when producers relocate. It also lowers signalling costs by up to 31%, reducing network overhead. Additionally, path optimization improves by 25%, leading to more efficient data routing. Packet loss decreases by 44% compared to KITE and 32% compared to PMSS, ensuring reliable data delivery. Finally, PMMM increases throughput by 17% over KITE and 12% over PMSS, improving network stability. These findings demonstrate that PMMM effectively addresses mobility challenges in NDN. This significant improvement highlights the PMMM's immense potential for future deployment, especially in the context of advanced technologies such as the Internet of Things (IoT), the Internet of Medical Things (IoMT), and sixth-generation (6G) mobile networks.

Keywords: Information-centric networking, Analytical modelling, Handoff, Mobility management packets.

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“The ink of the scholar is more sacred than the blood of the martyr.”

— Prophet Muhammad (peace be upon him)

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List of Abbreviations

4WARD	Forward
4G	Fourth Generation
AS	Autonomous System
BU	Binding Update
BA	Binding Acknowledgement
BT	BitTorrent
CAGR	Compound Annual Growth Rate
CCN	Content-Centric Networking
CDSBM	Control/Data Plane Split Based Mobility
CBM	Caching Based Mobility
CDN	Content Distribution Network
COAST	Content-Aware Searching retrieval and sTreaming
COMET	COntent Mediator architecture for content-aware nETworks
COMIT	Active Content Management at Internet Scale
CONET	Content Network
CONVERGENCE	Convergence Project
CR	Content Router
CS	Content Store
DNS	Domain Name System
DNSBM	Domain Name System Based Mobility
DONA	Data-Oriented Network Architecture
DPDR	Data Packets Delivery Ratio
DRM	Design Research Methodology
DS-I	Descriptive Study-I
DS-II	Descriptive Study-II
EB	Exabyte
EUFP7	European Union Research and Innovation program
FIB	Forwarding Information Base
GreenICN	Green Information Centric Networking
HIP	Host Identification Protocol
IBM	Indirection Based Mobility

ICN	Information Centric Networking
IETF	Internet Engineering Task Force
IP	Internet Protocol
IRTF	Internet Research Task Force
LISBM	Locator/Identifier Split Based Mobility
LFBL	Listen First Broadcast Later
MI	Mobility Interest
MU	Mobility Update
MobiNDN	Mobility Support Architecture for Named Data Networks
MIPv4	Mobile Internet Protocol Version 4
MIPv6	Mobile Internet Protocol Version 6
NDN	Named Data Networking
NetInf	Network of Information
NACK	Negative Acknowledgement
NS-3	Network Simulator version 3
NS-2	Network Simulator version 2
ndnSIM	Named Data Networking Simulator
NFD	NDN Forwarding Daemon
OMNeT++	Objective Modular Network Testbed in C++
OPML	Optimal Provider Mobility in Large-Scale
POA	Point of Attachment
PMSS	Producer Mobility Support Scheme
PSI	Public Subscriber Internet
PIT	Pending Interest Table
PSIRP	Publish-Subscribe Internet Routing Paradigm
PURSUIT	Publish Subscribe Internet Technology
PS	Partial Separation
PACK	Prefix Update
PS	Prefix Update Acknowledgement
PMC	Publisher Mobility Support
PNPCCN	Proactive Neighbor Pushing in Content-Centric Networks
PS	Prescriptive Study

RFC	Request for Comment
RH	Resource Handler
RP	Rendezvous Point
RD	Rendezvous Domain
RC	Research Clarification
RTT	Round Trip Time
SAIL	Scalable and Adaptive Internet Solution
SMM	Scalable Mobility Management
SDC	Software Define Controller
TCP	Transmission Control Protocol
TCP/IP	Transport Control Protocol/Internet Protocol
TS	Total Separation
TRIAD	Translating Relaying Internet Architecture Integrating Active Directories
UCL	University College London
URL	Uniform Resource Locator
UDP	User Datagram Protocol
US	United States
UUM	Universiti Utara Malaysia
VNI	Visual Networking Index
IoTs	Internet of Things
IoE	Internet of Everything
IoMTs	Internet of Medical Things
MANET	Mobile Ad hoc Network
VANET	Vehicular Ad hoc Network
6G	Six Generation

CHAPTER ONE

INTRODUCTION

This research is intended to resolve and contribute a solution to enhance the producer mobility support for Named Data Networking (NDN). Producer mobility is where the source of data moves to a new location, but the reference of Interest packets forwarding is still pointed to the previous location of the producer. The change of the producer location induces various issues such as long handoff latency, high signalling, Interest packet loss, and inefficient delivery path. This chapter aimed to highlight the issues or research gaps in the producer mobility domain then to propose a solution. This chapter is organized into different sections that initiate with Section 1.1 in which we cover the background of the study to provide comprehensive knowledge and fundamental issues of the Internet architecture. In Section 1.2, the research motivation is explained wherein it defines the NDN features, benefits and issues are discussed. In Section 1.3, the problem statement that provides the key issues of producer mobility in NDN architecture. In Section 1.4, research questions derived from the problem statement to specify the basic issue that needs to be addressed in producer mobility. Section 1.5 defines the research objectives to propose an efficient solution for NDN producer mobility problems. In Section 1.6, significance of the study and benefits of the present study are explained. In Section 1.7, scope of the study is presented to provide the logical conclusion and performance measurement of this research. Lastly, Section 1.8, describes the organization of the thesis that reveals the outline of this proposal.

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