ENHANCED MOBILITY MANAGEMENT SCHEME FOR MOBILE PRODUCER HANDOFF IN NAMED DATA NETWORKING

BY

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ABSTRACT

The problem of managing network mobility has been an open issue in network mobility management. This is because of the huge volume of multimedia contents across IP networks. The current IP architecture seems inadequate to continuously manage the ever-increasing number of mobile and network devices, that consumes and generate multimedia contents. This initiated and stimulated the concept of CCN/NDN to solve challenges faced in IP networks. Named Data Networking is a new content centric network architecture that can possibly tackle most issues of IP mobility and security. NDN approach is commonly identified under Information Concentric Network or Content Concentric Network and is centered on addressing contents by themselves using names, rather than assigning IP addresses to packets on hosts where information is located on the global internet. This thesis proposed a mobility management scheme with improved network availability and scalability for the mobile producer during and after inter-technology handoff. This is achieved by using rendezvous-based mobility management approach.

For network availability, anchorless (locator-free) approach is used for producer's connectivity during handoff for intra and inter access point change over. This ensures mobile producers' registration and location update as it successfully achieves mobile handoff within an outside the network core. Forwarding paths and labels are also enhanced with minimal signaling cost and using best route approach to ensure easy transmission and reception of Interest and Data contents between mobile producers and rendezvous servers.

For network scalability, simulation is used. The number of rendezvous server is increased for each simulation scenarios of pull, push, upload and shear to ensure traffic redistribution and by synchronizing the proposed scheme with scenario aware protocol. Each of the rendezvous server has an amount of data streams it can respond to in a network session when a mobile producer or consumer transmits its interest request. In the first scenario, four rendezvous nodes were deployed to implement the proposed number of data content streams in the NDN network. These data streams range between 100 to 1500 in each rendezvous node and is accessed multiple times to by producers and consumer for specified time interval. For the second scenario the number of rendezvous servers were increased to seven where number of data streams were maintained to 1500 in each rendezvous with maximum of 300 connection request per consumers and producers. For the third scenario, the number of consumers 10 and mobile producers are 15 to access 1500 maximum number of data streams in each rendezvous. In the final simulation link loss rate is at maximum of 10% and all other parameters were maintained constant based on first, second with 15% and third scenario with 23%. This can enable mobile producers to be able to retransmit their interest request in situation of total packet losses for at least three times. Based on the implementation, Algorithms are designed for network availability during and after successful mobile producer handoff, and for unique prefix name assignment. These are supported by an effective flowchart for clear description.

For the results, ndnSIM2.1 is used in coding the scenarios based on random way point movement model and the analysis is simulated in Linux environment. Wireshark is interfaced to observe some basic parameters such as average throughput, round trip time,

sequence number and window scaling all against time in seconds. In addition, analytical computation in python is achieved for cell residence time, handoff delay for number of data stream per rendezvous, packet loss for consumer, mobile producer and rendezvous server, signaling cost for consumer and mobile producers, and packet delivery cost and link loss.

ملخص البحث

كانت مشكلة إدارة تنقل الشبكة قضية مفتوحة في إدارة تنقل الشبكة. ويرجع ذلك إلى الحجم الهائل لمحتويات الوسائط المتعددة عبر شبكات IP. يبدو أن بنية IP الحالية غير كافية لإدارة العدد المتزايد باستمرار من الأجهزة المحمولة والشبكات، التي تستهلك محتويات الوسائط المتعددة وتولدها. وقد أدى هذا إلى بدء وتحفيز مفهوم CCN / NDN لحل التحديات التي تواجه شبكات IP. شبكة البيانات المسماة هي بنية شبكة جديدة تتمحور حول المحتوى يمكنها معالجة معظم مشكلات تنقل وأمان بروتوكول الإنترنت IP يتم تحديد نهج NDN بشكل شائع ضمن شبكة المعلومات المركزة أو الشبكة المركزة على المحتوى ويتمحور حول معالجة المحتويات بأنفسهم باستخدام الأسماء، بدلاً من تعيين عناوين IP للحزم على المضيفين حيث توجد المعلومات على الإنترنت العالمي. اقترحت هذه الرسالة مخططًا لإدارة التنقل مع توفر شبكة محسنة وقابلية التوسع لمنتج الهاتف المحمول أثناء وبعد التسليم بين التكنولوجيا. يتم تحقيق ذلك باستخدام نهج إدارة التنقل القائم على الالتقاء.

لتوافر الشبكة، يتم استخدام نهج عدم الارتكاز (الخالي من محدد المواقع) لاتصال المنتج أثناء التسليم لتغيير نقطة الوصول الداخلية ونقطة الوصول البينية. يضمن ذلك تسجيل المنتجين المتنقلين وتحديث الموقع لأنه يحقق بنجاح تسليم الأجهزة المحمولة داخل مركز خارجي للشبكة. يتم أيضًا تحسين مسارات إعادة التوجيه والتسميات بأقل تكلفة للإشارة وباستخدام أفضل نهج للمسار لضمان سهولة الإرسال والاستقبال لمحتويات الاهتمام والبيانات بين المنتجين المتنقلين وخوادم الالتقاء.

لتوسيع الشبكة، يتم استخدام المحاكاة. ويتم زيادة عدد خادم الالتقاء لكل سيناريوهات محاكاة للسحب والدفع والتحميل والقص لضمان إعادة توزيع حركة المرور ومن خلال مزامنة المخطط المقترح مع البروتوكول المدرك للسيناريو. يحتوي كل خادم ملتقى على قدر من تدفقات البيانات يمكنه الاستجابة لها في جلسة الشبكة عندما يرسل منتج أو مستهلك متنقل طلب الاهتمام الخاص به. في السيناريو الأول، تم نشر أربع عقد التقاء لتنفيذ العدد المقترح لتدفقات محتوى البيانات في شبكة .NDN تتراوح تدفقات البيانات هذه بين 100 إلى 1500 في كل عقدة التقاء ويتم الوصول إليها عدة مرات من قبل المنتجين والمستهلكين لفاصل زمني محدد. بالنسبة للسيناريو الثاني، تمت زيادة عدد خوادم التقاء إلى سبعة حيث تم الحفاظ على عدد تدفقات البيانات إلى 1500 في كل لقاء بحد أقصى 300 طلب اتصال لكل المستهلكين والمنتجين. بالنسبة للسيناريو الثالث، فإن عدد المستهلكين 10 والمنتجين المتنقلين 15 للوصول إلى الحد الأقصى لعدد تدفقات البيانات في كل لقاء. في المحاكاة النهائية، يبلغ معدل خسارة الوصلة 10٪ كحد أقصى، وتم الحفاظ على ثبات جميع المعلمات الأخرى بناءً على السيناريو الأول والثاني15٪ والثالث23٪. وهذا يمكن أن يمكّن المنتجين المتنقلين من إعادة إرسال طلب مصلحتهم في حالة إجمالي خسائر الحزمة لثلاث مرات على الأقل. بناءً على التنفيذ، تم تصميم الخوارزميات لتوفر الشبكة أثناء وبعد التسليم الناجح لمنتج الهاتف المحمول، ولتخصيص اسم بادئة فريد. يدعمها مخطط انسيابي فعال لوصف واضح.

بالنسبة للنتائج، يتم استخدام ndnSIM2.1 في ترميز السيناريوهات بناءً على نموذج حركة نقطة الطريق العشوائية ويتم محاكاة التحليل باستخدام البايثون في بيئة لينكس Linux تم ربط Wireshark بمراقبة بعض المعلمات الأساسية مثل متوسط الإنتاجية ووقت الذهاب والإياب ورقم التسلسل وقياس النافذة، كل ذلك مقابل الوقت بالثواني. بالإضافة إلى ذلك، يتم إجراء الحساب التحليلي في لوقت بقاء الخلية، وتأخير التسليم لعدد تدفق البيانات في كل موعد، وفقدان الحزمة للمستهلك والمنتج المحمول وخادم الموعد، وتكلفة الإشارة للمستهلكين والمنتجين المتنقلين، وتكلفة تسليم الحزم وفقدان الارتباط.

APPROVAL PAGE

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DECLARATION

I hereby declare that this thesis the result of my own investigations, except where otherwise stated. I also declare that it has not been previously or concurrently submitted as a whole for any other degrees at IIUM or other institutions.

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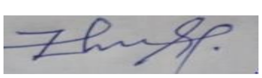
………..

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Date: 29 December 2021

This thesis is dedicated to my parents Professor Dr. Ahmed Hammawa Song, Hajiya Hauwa'u Ahmed, and to my supervisor Prof. Dr. Aisha Hassan Abdalla Hashim. I pray Allah (SWT) to provide them with more prosperous long life, health, bless their family entirely and have a happy Islamic ending.

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LIST OF SYMBOLS

C_r	Cell residence time
U_t	Epoch time
U_p	Pause time
U_c	Cell crossing
M_r	Mobility Rate
H_p, V_p	Horizontal & Vertical Path (numbers)
$H_l, V_l,$	Horizontal & Vertical length of dissection area
dh, dv	Distance of Horizontal& Vertical road
$N_{hr,vr}$	Number of Horizontal& Vertical road
Y_{max}	Maximum Y axis
S	Mobile Producer Speed
m	Row number of producers
n	Column number of producers
R_t	Resident time (Subnet)
λ_s	Arrival rate at average session time
τ	Encapsulation cost
k	Maximum Transmission Unit
T_{HD}	Total Handoff delay
L_d	Link delay
$P_{hd}^{P\ Mob}$	Partial handoff delay
$P(wlf)$	Probability of wireless link failure
L_{smp}	Link of the serving mobile producer
W_{wd} and W_{wl}	Bandwidth of the wired link and wireless link
wd and wl	Wired Wireless link
$H_{mr\ to\ ar}$	Hop distance between mobile router to access router
$T_{mag2}^{P\ Mob}$	Time of connection of mobile access gateway MAG
$T_d^{P\ Mob}$	Time delay for location update
S_l	Average network session length
M_r	Mobility rate
N_{smp}	Number of Serving Mobile Producer
T_{cell}	Total cell residence time
r_c	Radius of a cell
P_s	Average NDN producer speed
$C_{r(a)}$	Cell residence time (average)
H_{ag}	New access gateway registration
L_{hi}	Length of handoff initiation
L_{hACK}	Length of handoff acknowledgement

P_{wlf}	Probability of wireless link failure
H_{smp}	Access gateway of serving mobile producer
L_{smp}	Link to the serving mobile producer
wf	Weight factor
Σ	Covariance Proportionality constant for wired and wireless link

LIST OF ABBREVIATIONS

AR	Access Router
ALT	Automatic Link Transfer
AS	Autonomous System
BER	bit error rate
BLER	block error rate
BSP	Basic Support Protocol
BU	binding updates
CCN	Content Concentric Networking
CCL	Common Client Library
CGI	Cell Global Identification
CI	Cell Identification
CS	Content Store
CN	Corresponding Node
CoA	Care-of-Address
CMM	Community-Based Mobility Model
CSMA/CA	Carrier-Sense Multiple Access with Collision Avoidance
DECT	Digital Enhancements of Cordless Telephony
DMM	Distributed Mobility Management
DONA	Data-Oriented Network Architecture
DIDs	Decentralized Identifiers
eMBB	Enhanced Mobile Broadband
EBU	Early Binding Updates
ESN	Echo State Network.
FIB	Forwarding Information Base
GMM	Global Mobility Management
GNS3	Graphic Network Simulator
LMM	Local Mobility Management
HA	Home Agent
HN	Home Network
HLR	Home location register
HNP	Home Network Prefix
HI	Handover Initiation
HTTP	Hyper Text Transfer Protocol
ID	Identification
IP	Internet Protocol
IPv4	Internet Protocol Version 4
IPv6	Internet Protocol Version 6
IoT	Internet Devices
ICN	Information Concentric Networking
ISP	Internet Service Provider

LAI	Location Area Identification
LA	location Areas
LU	location update
LAC	Location Area Code
LMA	Local Mobility Anchorless-base
MA	Mobile Agent
MAC	Media Access Control
mMTC	massive Machine-type Communication
MNN	Mobile Network Node
MR	Mobile Routers
MN	Mobile Node
MSC	Mobile Switching Centre
MS	mobile station
MP	Mobile Producer
MCC	Mobile Country Code
MAHO	Mobile Assisted Handoff
MNC	Mobile Network Code
MNP	Mobile Network Prefix
MCHO	Mobile Controlled Handoff
Nack	Negative Acknowledgement
NCHO	Network Controlled Handoff
NCE	Name Component Encoding
NEMO	Network Mobility
NDN	Named Data Networking
NDO	Named Data Object
NRS	Name Resolution System
NS-3	Network Simulator version 3
ndnSIM	Named Data Networking Simulator
OSPF	Open Shortest Path First
PACS	Personal Access Communications System
PIT	Pending Interest Table
PoA	Point of Attachment
PLMN	Public Land Mobile Network
PURSUIT	Publish Subscribe Internet Technology
P2P	Point to Point
PMSS	Producer Mobility Support Service
QoS	Quality of Service
RFC	Request for Comments
RIP	Routing Internet Protocol
RSS	Radio Signal Strength
RWM	Random Waypoint Movement
RTS/CTS	Request to Send/Clear to Send
RV	Rendezvous Server
SAIL	Scalable and Adaptive Internet Solutions
SIR	signal-to-interference ratio
SMR	Serving Mobile Router

STA	State Transition Array
SUMO	Simulation of Urban Mobility
TCP/IP	Transport Control Protocol/Internet Protocol
TST	Time Slot Transfer
TVLs	Type-Length-Values
TDMA	Time Division Multi Access
UDP	User Datagram Protocol
URL	Uniform Resource Locator
URLLC	Ultra-reliable and Low-latency Communication
VLR	Visitor Location Register
VI	Virtual Interface
Wi-Fi	Wireless Fidelity
WiMAX	Worldwide Interoperability for Microwave Access
W3C	World Wide Web Consortium

CHAPTER ONE

BACKGROUND

1.1 INTRODUCTION

The present-day Internet focus on IP addresses between host to host on a communication network (Al-Adhaileh, Muchtar, & Abdullah, 2020). This means a host must identify its intended destination accurately to retrieve resources on the Internet. The Internet increasingly experiences more and more information dissemination, mobile devices and exponential increase in number of online users (Sharma & Krishna, 2019). Traffic on the Internet varies in the range of multimedia, website pages, streaming real-time videos etc. As a result, the Internet currently seems insufficient to accommodate these exponential growths.

The TCP/IP network architecture may not efficiently serve the growing number of devices in the near future. This is because of several challenges faced, like when a user is searching for a particular packet, an information has to be mapped to a host whereby the domain name system translates to an IP address (Islam S. , Hashim, Nadia, & Kamarul, 2018). This long process creates high computational delay, bandwidth wastage, etc. Another open issue the IP framework suffers is the anchored technique of its mobile router that serve a moving Internet device (Islam S., Hashim , Hassan, & Razzaque, 2019). This makes mobile devices suffer seamless connection when on-the-move. Also, lack of anchorless mobile router makes a network prone to attack as hackers can identify an actual position of a router to attack and hijack easily. IP routers are stateless in their data plane and has no characteristics for caching (storage) (Sivchenko, Xu, & Habermann, 2005).