ROUTE OPTIMIZATION ENHANCEMENT SCHEMES FOR MANEMO NETWORKS

BY

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ABSTRACT

The increasing demand for global Internet connectivity has increased the demand for Network Mobility (NEMO). Internet Engineering Task Force (IETF) has introduced the NEMO Basic Support (NEMO BS) protocol to address the limitations of Mobile IPv6 (MIPv6) protocol to support the complete IP network, which is Mobile Router (MR) as an alternative of a single host. Under NEMO BS protocol, all data packet to/from Mobile Network Nodes (MNNs) must go through Bidirectional Tunnel (BT) that established between Mobile Router and its Home Agent (MR-HA). The Home Agent then encapsulates these packets and forwards them to the MR. The MR, in turn, decapsulates the packets and forwards them to the MNN. And thus, the suboptimal and inefficient routing path would be generated especially in Nested NEMO networks (Pinball problems). The difficulties associated with the packet delivery are, the packet overhead and the route delay which lead to the traffic congestion and then bottleneck links issues which are considered as Route Optimization (RO) and Multihoming concerns. Therefore, two schemes have been proposed. The first is for MANET for NEMO (MANEMO) Routing Optimization (RO), and the second proposed scheme is Multihoming of MANEMO. After that, the proposed MANEMO RO and Multihoming schemes are presented as (MROM) scheme. The proposed MROM scheme is a layer three solution to support RO and Multihoming for mobile networks. Firstly, the proposed MANEMO RO scheme comes as a complementing solution for the pinball problem, by avoiding the bidirectional MR-HA tunnel that optimizes the transmission of packets between an MNN/MR and a Corresponding Node/Home Agent (CN/HA). A discussion is presented about RO and Multihoming issues for Nested NEMO such as tunneling redundancy, HA dependency, processing delay, bottleneck, traffic congestion, ER selection, and scalability consideration in the design. In order to address suboptimal NEMO RO, this work utilizes NEMO Centric MANEMO (NCM) protocol in addition to Proxy Home Agent (PHA). Additionally, the thesis proposes the design to address Nested NEMO issues in a post disaster scenario by using PHA in the infrastructure and using Neighbor Discovery protocol (TDP/NINA) for communication localization. Thus, the signaling message flow and the algorithm are written to give the proposed scheme more flexibility. The existing NEMO- BSP is capable of registering only a single primary Care of Address (CoA) of a MR during movement between different networks. Thus, when this link fails, a problem of network connectivity is created due to there is no secondary HA to keep a continuous Internet connectivity in NEMO. As a result, the proposed MROM applying a multihoming technique at any place, anywhere to provide uninterrupted Internet connection in NEMO has become a significant area of research. When a mobile network is multihomed, it is possible to achieve some features; namely, increased availability, balanced traffic load with flow distribution through simultaneous connectivity to access a router (Exit Router, ER). The research evaluation is done using analytical approach and simulation. In the analytical approach, the performance metrics are to be identified and evaluated. In the simulation approach, the Wireshark is used with NS-3 to generate the simulation results. The analytical result shows that the proposed scheme reduces average handoff cost by 64% lower compared to the NEMO-BSP and PNEMO. The simulation is done using Network Simulator version 3 (NS-3). The simulation result shows that the proposed scheme outperforms the standard NEMO BSP and P-NEMO in terms of packet loss

(less than 1%) and handoff delay (average improvement by 76%). MROM routing scheme remains lower than NEMO BS by 42% to 67%. This is because proposed MROM scheme does not update all HAs for MRs handoffs (just PHA is updated and it transmits a copy of this update to other HAs), while NEMO Basic Support Protocol needs to update MN_HA and MR_HA for all handoff.

خلاصة البحث

ادى الطلب المتزايد على الشبكة العالمية للانترنت الى زيادة الطلب على الشبكات المتنقلة. لقد قام مهندسي شبكات الانترنت باستخدام بروتوكول الدعم الاساسي لتنقل الشبكة لمعالجة محدودية بروتوكول (MIPv6) وذلك من اجل دعم برتوكوللات الانترنت الكاملة، وهي عبارة عن جهاز توجيه محمول كبديل لمضيف واحد. وبموجب هذا البرتوكول ال (الانترنت المتنقل) يجب أن تمر جميع حزم البيانات من / إلى عقد شبكة المحمول عبر نفق ثنائي الاتجاه تم إنشاؤه بين جهاز التوجيه المحمول ووكيل المنزل. يقوم وكيل المنزل بعد ذلك بتغليف هذه الحزم وإرسالها إلى جهاز التوجيه المحمول (الراوتر). يقوم جهاز التوجيه المحمول (الراوتر) بفك الحزم وارسالها الى عقد شبكة المحمول سيتم إنشاء مسار التوجيه الردئ والغير كفوء وخاصة في الشبكات المتنقلة المتداخلة. ان الصعوبات المرتبطة بتسليم الحزم تتمثل بالعبء على الرزمة، وتأخير المسار الذي يؤدي إلى الازدحام المروري التي تعتبر بمثابة "تحسين المسار (RO) "ومخاوف تعدد المسارات. ولذلك، اقترح مخططين. الاول مخصص لتحسين المسار للشبكة المتنقلة والثاني متعدد الطرق. بعد ذلك ، يتم تقديم مخططات متعددة الطرق. ان المخطط المقترح هو حل من الطبقة الثالثة لدعم مسار التوجيه المتعددة الطرق. أولاً ، يأتي المخطط المقترح كحل مكمل لمشكلة الكرة والدبابيس ، من خلال تجنب النفق ثنائي الاتجاه الذي يعمل على تحسين نقل الحزم بين الراوتر المتنقل/ عقد الشبكة المتنقلة والعقدة المقابلة /الشبكة الأم . تمت مناقسة مشاكل تحسين المسار والمتعددة الطرق للشبكات المتنقلة مثل التكرار النفقي، واعتماد وكيل المنزل وتأخير المعالجة ، والاختناق ، وازدحام المرور اعتبار قابلية التوسع في التصميم. من اجل تحسين مسار الشبكات المتنقلة التي هي دون المستوى الامثل يستخدم هذا البروتوكول (الشبكات المتنقلة) بالإضافة إلى وكيل المنزل. بالإضافة إلى ذلك ، تقترح الأطروحة تصميمًا لمعالجة مشكلات الشبكة المتنقلة

المتشعبة في سيناريو ما بعد الكارثة باستخدام خادم مرجعي اساسي في البنية التحتية واستخدام بروتوكول اكتشاف الجوار لتوطين الاتصالات. وبالتالي تتم كتابة تدفق رسائل الاشارات والخوارزمية لمنح المخطط المقترح مزيدًا من المرونة. ان الشبكات المتنقلة. ان الشبكات المتنقلة الحالية قادر على تسجيل رعاية أولية واحدة فقط للعناوين الخاصة بالرنين المغناطيسي أثناء التنقل بين الشبكات المختلفة. وبالتالي ، عندما يفشل هذا الارتباط ، يتم إنشاء مشكلة اتصال الشبكة بسبب عدم وجود خادم مرجعي ثانوي للحفاظ على اتصال إنترنت مستمر في الشبكات المتنقلة. وبذلك اصبح الراوتر المتنقل المقترح لتقنية الإرسال المتعدد في أي مكان وفي أي مكان لتوفير اتصال إنترنت غير منقطع في الشبكات المتنقلة مجالًا مهمًا للبحث .عندما تكون شبكة المتنقلة متعددة طرق الاتصال ، فمن الممكن تحقيق بعض الميزات ؛ وهي زيادة التوافر وحمل المرور المتوازن مع توزيع التدفق من خلال الاتصال المتزامن للوصول إلى جهاز التوجيه (موجه الخروج). يتم تقييم البحث باستخدام النهج التحليلي والمحاكاة .في النهج التحليلي ، يجب تحديد مقاييس الأداء وتقييمها .في نهج المحاكاة ، يتم استخدام الاسلاك لتوليد نتائج المحاكاة .تظهر النتيجة التحليلية أن المخطط المقترح يقلل من متوسط تكلفة التسليم بنسبة 64٪ مقارنةً بـ الشبكات المتنقلة. تتم المحاكاة باستخدام محاكي الشبكة الإصدار 3. تظهر نتيجة المحاكاة أن المخطط المقترح يتفوق على النموذجين السابقين من حيث فقدان الحزمة (أقل من 1٪) وتأخير التسليم (متوسط التحسين بنسبة 76٪ .(يظل مخطط توجيه المسار اقل من بروتوكول الدعم الاساسي بنسبة 42٪ إلى 67٪ .هذا لأن مخطط توجيه المسار المقترح لا يقوم بتحديث جميع الخوادم المرجعية لعمليات التسليم (يتم تحديث الخادم المرجعي الرئيسي للموجه الجوال فقط ويقوم بإرسال باعادة ارسال هذا التحديث إلى الخوادم المرجعية الأخرى) ، بينما يحتاج باستخدام بروتوكول الدعم الاساسي للشبكات المتنقلة إلى تحديث لجميع عمليات التسليم.

APPROVAL PAGE

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DECLARATION

I hereby declare that this thesis is the result of my own investigation, 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.

Ahmed Ayoob Mousa

Signature………………………… Date 29/03/2021

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LIST OF ABBREVIATIONS

AAA	Authentication, Authorization and Accounting
ACK	Acknowledgement Message
AP	Access Point
AR	Access Router
AS	Autonomous System
BaCK	Binding Acknowledgement
BC	Binding Cache
BCE	Binding Cache Entry
BGP	Border Gateway Protocol
BT	Bidirectional Tunnel
BU	Binding Update
BS	Base Station
CBU	Copy Binding Update
CE	Correspondent Entity
CFMR	Current Flow-enabled MR
CN	Correspondent Nodes
CoA	Care-of-Address
CR	Correspondent Router
DA	Destination Address
DAD	Duplicate Address Detection
DATT	Different Access Technology Type
DUMBO	Digital Ubiquitous Mobile Broadband OLSR
E(e)	Egress Interface
ER	Exit Router
ER_HA	Home Agent for Exit Router
FMIPv6	Fast Mobile IPv6
FMNP	Flow Mobile Network Prefix
FHMIPv6	Fast Hierarchical Mobile IPv6
FLMA	Flow-enable Local Mobility Anchor Point

FR	Fixed Router
HA	Home Agent
H/O M	Handover Manager
H/O	Handover
HAHA	Home Agent to Home Agent protocol
HAMR	Home Agent of Mobile Router
HAcK	Handover Acknowledgement
HI	Handover Initiation
HMIPv6	Hierarchical Mobile IPv6
HoA	Home-of-Address
HNA	Network Association
HNP	Home Network Prefix
HQ	Headquarter
I(i)	Ingress Interface
ICMPv6	Internet Control Message Protocol version 6
IEEE	Institute of Electrical and Electronics Engineers
IETF	Internet Engineering Task Force
IGW	Internet Gateway
iMANET	Intelligent MANET
IPBA	Initial Proxy Binding Acknowledgement
IPBU	Initial Proxy Binding Update
IPv6	Internet Protocol version 6
ITS	Intelligent Traffic System
ITU-T	International Telecommunication Union-Telecom
MAC	Medium Access Control
MANEMO	MANET for NEMO
MANET	Mobile Ad hoc Network
MCM	MANET-Centric MANEMO
MD	Movement Detection
MAG	Mobility Anchor gateway
MFS	MANEMO Fringe Stub
MIPv6	Mobile IPv6

MIRON	Mobile IPv6 Route Optimization for NEMO
MN	Mobile Node
MNN	Mobile Network Node
MNP	Mobile Network Prefix
MR	Mobile Router
MR_HA	Home Agent for Mobile Router
NAM	Network AniMator (Network simulation visualization tool)
NAV	Network Allocation Vector
NCM	NEMO-centric MANEMO
NEMO BSP	Network Mobility Basic Support Protocol
NEMO ES	NEMO Extended Support
NEMO	Network Mobility
NERON	NEMO Route Optimization for Nested networks
NFMR	New Flow-enabled MR
NINA	Network In Node Advertisement
NINO	Network In Node Option
NS-3	Network Simulator 3
LAN	Local Area Network
LFN	Local Fixed Node
LMN	Local Mobile Node
LMA	Local Mobility Anchor Point
LU	Location Update
L2	Layer Two
L3	Layer Three
ONEMO	Optimized NEMO
OTCL	Object Tool Command Language
PAN	Personal Area Network
PBA	Proxy Binding Acknowledgement
PBU	Proxy Binding Update
PD	Prefix Delegation
PHA	Proxy Home Agent
PHY	PHYsical Layer

IP	Internet Protocol
RR	Return Route Ability
RRH	Reverse Routing Header
RA	Router Advertisement
RS	Router Solicitation
RS	Recursive Scheme
RTS	Ready To Send
SA	Source Address
SIP	Session Initiation Protocol
SMR	Serving Mobile Router
TCL	Tool Command Language
TCP	Transmission Control Protocol
TDP	Tree Discovery Protocol
TIO	Tree Information Option
QoS	Quality of Service
UDP	User Data Protocol
UMA	Unified MANEMO Architecture
UMTS	Universal Mobile Telecommunications System
V2I	Vehicle-to-Infrastructure
V2V	Vehicle-to-Vehicle
VANET	Vehicle Ad hoc Network
VMN	Visiting Mobile Node
VPN	Virtual Private Network
WG	Working Group
WI-FI	Wireless Fidelity
WIMAX	Worldwide Interoperability for Microwave Access

LIST OF SYMBOLS

N_{SMR}	Number of the serving MR
N_{VR}	Number of vertical road
N_{HR}	Number of horizontal road
S_{hd}	Distance of horizontal road
S_{vd}	Distance of vertical road
μ_h	MR mobility rate
T_{SMR}	Cell residence time
T_{LS}	Link switching delay
P_{wlf}	Probability of wireless link failure
B_{wl}	Bandwidth of the wireless link
B_{wd}	Bandwidth of the wired link
T_{wl}	Wireless link delay
t_d	Wired link delay
$H_{X\text{-}Y}$	Hop distances between x and y
L_Z	Length of the Z message
τ	Tunneling weight factors
λ_S	Average Session Length
σ	Packet Loss weight factor
β	Buffering weight factor
ω	Wireless weight factor

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

The Internet Engineering Task Force (IETF) introduced Mobile IPv6 protocol to support host mobility (individual IP devices) for laptops, mobile phones and PDAs (Johnson, Perkins, and Arkko, 2004). MIPv6 maintains session continuity between a Mobile Node (MN) and its Correspondent Node (CN) regardless of the MN current point of attachment to the Internet. MIPv6 uses a Home Agent (HA) to send/receive packets between the current location of the MN and its CN. The base specifications of Mobile IPv6 include a Route Optimization (RO) scheme called the Return Routability (RR) Procedure. It allows an MN to send a Binding Update (BU) packet to its CNs. Packets are further routed between MNs and their CNs. While this optimization minimizes latency of the communication and improves network performances, it also introduces several problems such as modifications of end-nodes, complexity, and server overload (Wakikawa 2009). More in-depth research proven the lack mobility support with the network known as Network Mobility support (NEMO). Therefore, the IETF has established a "NEMO Work Group" to offer a basic mobility solution based on the concept of MIPv6 protocol. That is to support a complete IP network, which is Mobile Router (MR) instead of a single host. The basic principle of Network Mobility (NEMO) is enable Mobile Networks Nodes (MNNs) maintain connectivity on the Internet even when a Mobile Router (MR) moves to another position (Devarapalli, V., Wakikawa, R., Petrescu, A. & Thubert, P. 2005). However, multiple solutions are required when working with heterogenous networks (e.g. networks with multiple subnets and Nested mobile networks). In order to manage the mobility of an entire network, an MR is considered the main mobile entity in the NEMO Basic Support (NEMO BS) model.