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Generic Route Optimization Model for NEMO Extended Sup
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Status of this Memo

Abstract

In this memo, we introduce the generic Route Optimization (
model that can be used as a framework to evaluate the exist
models. Then, we analyze typical RO problems by virtue of t
we discuss on the feasibility of achieving a unified RO in

and enumerate the issues that should be cleared for the pur
that.

Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHA
"SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONA
this document are to be interpreted as described in RFC-211

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1. Introduction

NEMO Basic Support Protocol [15] would suppose to support t transparent mobility to mobile network nodes (MNNs) in mobi networks by using MR-HA bi-directional tunnel. However, inh due to the use of the bi-directional tunnel, there are some of route optimization problem [14] that need our attention.

RO problems have a common property that there is an optimiz but it cannot be used due to support the transparent mobili the IP terminals. While preserving the goals of Mobile IP [NEMO Basic [15], it is impossible to realize RO without int the tunnel-based virtual path over IP routing through some extensions or new functionalities of routing facilities. Th the reason why the existing proposed solutions for RO at le tunnel-based packet redirection or re-routing mechanism in extended routing facilities such as Correspondent Router (C

As a requirement about RO, we argue that RO in NEMO should provided by a unified solution which can solve most of RO p by applying the same principle to the routing facilities su MR, CR. If each different RO solution is used to solve each problem, it will produce the protocol redundancy and comple the routing facilities.

In this memo, we introduce the generic RO model that can be a framework to evaluate the existing RO models. Then, we an typical RO problems by virtue of the generic RO model. And, discuss on the feasibility of achieving a unified RO in NEM enumerate the issues that should be cleared for the purpose

2. Generic Route Optimization Model

Route Optimization in NEMO means that one routing entity us tunnel to redirect the original packets to the other routin that is most closely located from the destination. To enabl route optimization, two routing entities must recognize eac in other words, anyone among them should feel the need of R and initiate the signaling procedure to make an IP tunnel b them. We can define such an IP tunnel as `RO Tunnel (ROT)` context because it is established for the purpose of route optimization in NEMO. This is like the basic principle of M In Mobile IP, MN detects its movement and initiates BU to H an analogy can be extended to RO problem in NEMO. In this p view, we can extract some of statements characterizing how achieve RO tunnel. For example, which routing facilities ca initiate RO tunnel? What information does trigger such a RO

How can the trigger information be delivered to the initiat tunnel? And so on. The answer to those of questions depends problem spaces [14] and the proposed solutions [4][5][19][2 each problem space.

The attributes of RO tunnel can concretely well express the context including the purpose of RO, the operation of RO, a effectiveness of RO.

```
         TE[1]        TS[0..n]    TR[0..n]    TE[1]
         +--+---------+--+--------+--+--------+--+
     ====|XX|=========|XX|========|==|========|XX|====
         +--+---------+--+--------+--+--------+--+

           XX: Tunnel Processing (Encap./Decap.)
           TE: Tunnel Endpoint
           TS: Tunnel Switcher
           TR: Tunnel Relay
```

Fig.1 Generic RO Tunnel (ROT) Model

Fig.1 shows the generalized ROT model. ROT can be made of a two TEs. In here, TE is a router or host which is allowed t initiate or terminate the RO tunnel in the view of route optimization. According to the type of ROT, ROT can include

more TS for switching an incoming tunnel to an outgoing tun
that point, zero or more TR for relaying the tunneled packe
next intermediate point. As of TR, The difference is that i
operates a routing mechanism, such as Source Routing using
header [10], based on the packet header information without
knowledge of the end-to-end tunneling, while TS processes t
tunnel switching based on a given tunnel mapping informatio
consistently maintained in that point by interacting with o
tunnel endpoints.

From the general ROT model, we can drive the following attr
which can be exploited to characterize a specific RO model.

RO Initiator (ROI)

We need to identify which TE among two TEs can be the in
in making a RO tunnel. This parameter depends on the app
scheme. In one RO scheme, MR is only the initiator, on t
hand, HA and CR can be the initiator in the other RO sch

RO Responder (ROR)

We need to identify which routing facilities can be the
responder in making a RO tunnel. This parameter also dep
the applied RO scheme.

RO Trigger Source (ROTS)

The RO initiator (ROI) is recognized for the need of RO
this information. For example, an explicit RO bit in the
header can be used to force the receiver to start the RO

RO Responder Information (RORI)

This information is used for the RO initiator (ROI) to i
the RO responder (ROR). It would include the address inf
of the moving entity such as MR, or the address informat
the correspondent nodes.

RO Discovery Mechanism (RODM)

This mechanism describes that how RORI can be delivered
RO initiator (ROI). In other words, ROI can get RORI by
this discovery mechanism. For example, if ROI itself try
its ROR using IPv6 anycast address, RORI becomes an addr
ROR and we can say that RODM is IPv6 anycasting mechanis

RO Tunnel Type (ROTT)

ROTT can be classified as the followings: Simple ROT (Si
Switched ROT (SwROT), Releyed ROT (ReROT). SiROT consist
only two TEs. SwROT consists of one or more TS between t
ReROT consists of one or more TR between two TEs. For ex
we can say that RRH [4] uses ReROT as RO Tunnel Type, HM
uses SwROT.

More attributes to be defined.

3. The Analysis of RO Problems in NEMO

In this section, we analyze typical RO problems in NEMO usi
generic ROT model.

3.1 RO in the infrastructure

```
    TE[1]                                TE[1]
    +--+---------------------------------+--+
====|XX|=================================|XX|====
    +--+---------------------------------+--+
```

Fig.2 SiROT based RO in the infrastructure

Fig.2 shows the simple RO in the infrastructure. This RO mo
used in ORC [19]. According to the generic ROT model, the f
formulation is possible.

TE: Mobile Router (MR), Optimized Route Cache (ORC) Router
ROI: MR
ROR: ORC Router
ROTS: the packet sent from any CN via MR-HA default tunnel
RORI: the global IPv6 address of ORC Router
RODM: IPv6 anycast addressing
ROTT: SiROT

Above attributes compactly describes that this RO implement
between MR and ORC Router, and MR initiates the signaling p
for ROT to ORC Router after getting the global IPv6 address
Router through IPv6 anycast addressing. This RO model also
some RO approaches, such as C-Side Router or Correspondent
(CR), mentioned in RO-Taxonomy [14]. To include those of RO
approaches, we can loosely redefine above attributes as fol

TE: Mobile Router (MR), Optimized Route Cache (ORC) Router,
Router, Correspondent Router (CR)
ROI: MR
ROR: ORC Router, C-Side Router, CR
ROTS: the packet sent from any CN via MR-HA default tunnel
RORI: the global IPv6 address of ROR
RODM: IPv6 anycast addressing
ROTT: SiROT

```
        TE[1]                      TS[1]       TE[1]
        +--+---------------------+--+--------+--+
    ====|XX|=====================|XX|========|XX|====
        +--+---------------------+--+--------+--+
```

Fig.3 SwROT based RO in the infrastructure

Fig.3 shows extended RO in the infrastructure. This RO mode

includes one TS entity and two TEs. Distributed Anchor Rout
described in RO-Taxonomy [14] can be expressed as this mode
below.

TE: Mobile Router (MR), C-Side Anchor Router
TS: M-Side Anchor Router (a.k.a Mobility Anchor Point in HM
ROI: Not mentioned
ROR: Not mentioned
ROTS: Not mentioned
RORI: Not mentioned
RODM: Not mentioned
ROTT: SwROT

In this case, most of attributes in the ROT model are not
determined, so it is required to deeply understand this RO
and derive its viable solution.

3.2 Nested Tunnels Optimization (NTO)

NTO can be modeled like Fig.4 by using the ROT model. For e
the attributes of RRH [4] model are as follows:

```
       TE[1]                       TR[1..n]    TE[1]
       +--+---------------------+--+--------+--+
   ====|XX|=====================|==|========|XX|====
       +--+---------------------+--+--------+--+
```

Fig.4 ReROT based NTO

TE: Mobile Router (MR), Home Agent (HA)
TR: MR (via Source Routing)
ROI: MR
ROR: HA
ROTS: TIO option in RA [14]
RORI: Nested Path Information like MR3->MR2->MR1->HA3
RODM: Using Reverse Routing Header (RRH)
ROTT: ReROT

Similarly, ARO [5] can be expressed as follows:

TE: Mobile Router (MR), Home Agent (HA)
TR: MR (via Source Routing)
ROI: MR

ROR: HA
ROTS: BU with ARO option, Recursive Binding Update by ances
RORI: Nested Path Information like MR3->MR2->MR1->HA3
RODM: Using Access Router Option (ARO) & Recursive BU
ROTT: ReROT

4. Toward to a unified route optimization in NEMO

There are some efforts for Route Optimization (RO). For RO routing infrastructure, some approaches such as VIP [17], O require a special router or the extension of the existing r which can handle the packet redirection to gain RO effect. schemes belong to this category can be applied to both Mobi and NEMO in IP routing infrastructure. On the other hand, T other kinds of the NEMO-specific RO problem. [14] well defi problem spaces of NEMO and briefly analyzes the proposed in solutions. Typically, one of NEMO-specific RO problem is a tunneling problem that can be formed due to the network mob Most of proposed solutions are for solving that problem. As it's not easy to say how RO problems in NEMO can be best so the reasonable manner. However, the sure thing is that curr proposed solutions can be applied only to one problem space That is an uncomfortable and unnatural facet in supporting network mobility. We need a simple and effective, unified r optimization scheme for network mobility.

With the help of the ROT model, we can evaluate whether or there is the feasibility of achieving a unified route optim in NEMO, and enumerate the issues that should be cleared fo purpose of that. As a unified RO model, let us illustrate o example as Fig.5. In here, TR can be zero. That is only dif in comparing with Fig.4. However, this trivial difference i model implies that this model can support SiROT based RO in infrastructure as well as ReROT based NTO. PCH [20] approac belongs to this model.

```
          TE[1]                        TR[0..n]    TE[1]
          +--+---------------------+--+--------+--+
      ====|XX|=====================|==|========|XX|====
          +--+---------------------+--+--------+--+
```

Fig.5 A unified RO supporting ReROT as well as SiROT

As an instance of a unified RO, The attributes of PCH [20] can be summarized as follows:

TE: Mobile Router (MR), Home Agent (HA), Correspondent Rout
TR: MR (via Source Routing)
ROI: CR, HA
ROR: MR
ROTS: Receiving the packet with Path Control Header (PCH)
RORI: Nested Path Information like MR1-MR2-MR3, contained i
RODM: PCH Piggybacking by HA
ROTT: SiROT+ReROT

5. Open Issues

? Functional entities involving in RO

? Source routing in the inside of nested mobile network

? Considerations on RO in multi-homed mobile networks

? Performance / Evaluation Metric for RO

TBD

6. Security Considerations

TBD

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