

NEMO Working Group
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Generic Route Optimization Model for NEMO Extended Sup
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Abstract

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

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

R0 problems have a common property that there is an optimization problem but it cannot be used due to support the transparent mobility of the IP terminals. While preserving the goals of Mobile IP [[15](#)] and NEMO Basic [[15](#)], it is impossible to realize R0 without introducing the tunnel-based virtual path over IP routing through some extensions or new functionalities of routing facilities. This is the reason why the existing proposed solutions for R0 at least use the tunnel-based packet redirection or re-routing mechanism in extended routing facilities such as Correspondent Router (C

As a requirement about R0, we argue that R0 in NEMO should be provided by a unified solution which can solve most of R0 problems by applying the same principle to the routing facilities such as MR, CR. If each different R0 solution is used to solve each problem, it will produce the protocol redundancy and complicate the routing facilities.

In this memo, we introduce the generic R0 model that can be used as a framework to evaluate the existing R0 models. Then, we analyze typical R0 problems by virtue of the generic R0 model. And, we discuss on the feasibility of achieving a unified R0 in NEMO and enumerate the issues that should be cleared for the purpose

2. Generic Route Optimization Model

Route Optimization in NEMO means that one routing entity uses an IP tunnel to redirect the original packets to the other routing entity that is most closely located from the destination. To enable route optimization, two routing entities must recognize each other. In other words, anyone among them should feel the need of RTO and initiate the signaling procedure to make an IP tunnel between them. We can define such an IP tunnel as 'RO Tunnel (ROT)' in this context because it is established for the purpose of route optimization in NEMO. This is like the basic principle of MIPv6. In Mobile IP, MN detects its movement and initiates BU to HA. In an analogy can be extended to RO problem in NEMO. In this paper, we view, we can extract some of statements characterizing how to achieve RO tunnel. For example, which routing facilities can initiate RO tunnel? What information does trigger such a RO tunnel?

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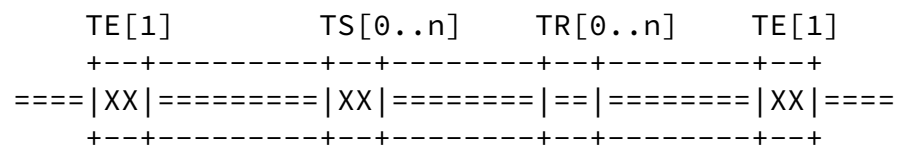
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How can the trigger information be delivered to the initiator to initiate a tunnel? And so on. The answer to those of questions depends on the problem spaces [14] and the proposed solutions [4][5][19][20] in each problem space.

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



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 sequence of components. In here, TE is a router or host which is allowed to 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 tunnel at that point, zero or more TR for relaying the tunneled packets to the next intermediate point. As of TR, The difference is that it operates a routing mechanism, such as Source Routing using the packet header [10], based on the packet header information without knowledge of the end-to-end tunneling, while TS processes the tunnel switching based on a given tunnel mapping information consistently maintained in that point by interacting with the tunnel endpoints.

From the general ROT model, we can derive the following attributes 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 initiator in making a RO tunnel. This parameter depends on the applied scheme. In one RO scheme, MR is only the initiator, on the other hand, HA and CR can be the initiator in the other RO scheme.

RO Responder (ROR)

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

RO Trigger Source (ROTS)

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

RO Responder Information (RORI)

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

RO Discovery Mechanism (RODM)

This mechanism describes that how RORI can be delivered R0 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 address ROR and we can say that RODM is IPv6 anycasting mechanism.

R0 Tunnel Type (ROTT)

ROTT can be classified as the followings: Simple ROT (SiROT), Switched ROT (SwROT), Releyed ROT (ReROT). SiROT consist only two TEs. SwROT consists of one or more TS between two TEs. ReROT consists of one or more TR between two TEs. For example we can say that RRH [4] uses ReROT as R0 Tunnel Type, HM uses SwROT.

More attributes to be defined.

3. The Analysis of R0 Problems in NEMO

In this section, we analyze typical R0 problems in NEMO using generic ROT model.

3.1 R0 in the infrastructure

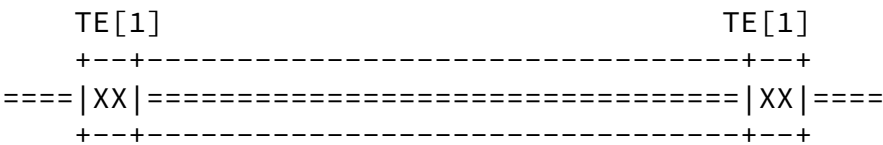


Fig.2 SiROT based R0 in the infrastructure

Fig.2 shows the simple R0 in the infrastructure. This R0 model is used in ORC [19]. According to the generic ROT model, the following 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 R0 implements signaling path between MR and ORC Router, and MR initiates the signaling path for ROT to ORC Router after getting the global IPv6 address of ORC Router through IPv6 anycast addressing. This R0 model also includes some R0 approaches, such as C-Side Router or Correspondent Router (CR), mentioned in R0-Taxonomy [14]. To include those of R0 approaches, we can loosely redefine above attributes as follows.

TE: Mobile Router (MR), Optimized Route Cache (ORC) Router, C-Side 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

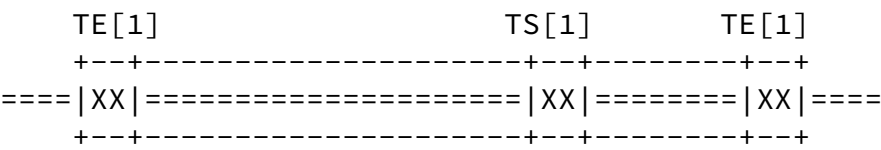


Fig.3 SwROT based R0 in the infrastructure

Fig.3 shows extended R0 in the infrastructure. This R0 model is used in ORC [19]. According to the generic ROT model, the following formulation is possible.

includes one TS entity and two TEs. Distributed Anchor Router described in R0-Taxonomy [14] can be expressed as this model 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 R0 and derive its viable solution.

3.2 Nested Tunnels Optimization (NTO)

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

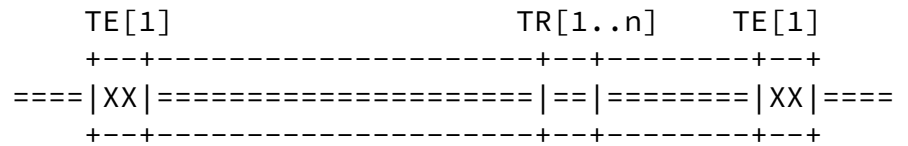


Fig.4 ReROT based NTO

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 ancestors

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 in mobile routing infrastructure, some approaches such as VIP [17], OMA [18], etc. require a special router or the extension of the existing router which can handle the packet redirection to gain RO effect. These schemes belong to this category can be applied to both Mobile IPv6 and NEMO in IP routing infrastructure. On the other hand, there are other kinds of the NEMO-specific RO problem. [14] well defines the problem spaces of NEMO and briefly analyzes the proposed solutions. Typically, one of NEMO-specific RO problem is a tunneling problem that can be formed due to the network mobility. Most of proposed solutions are for solving that problem. As a result, it's not easy to say how RO problems in NEMO can be best solved in the reasonable manner. However, the sure thing is that current 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 route optimization scheme for network mobility.

With the help of the ROT model, we can evaluate whether or not there is the feasibility of achieving a unified route optimization in NEMO, and enumerate the issues that should be cleared for the purpose of that. As a unified RO model, let us illustrate our example as Fig.5. In here, TR can be zero. That is only difference in comparing with Fig.4. However, this trivial difference in the model implies that this model can support SiROT based RO in mobile infrastructure as well as ReROT based NEMO. PCH [20] approach belongs to this model.

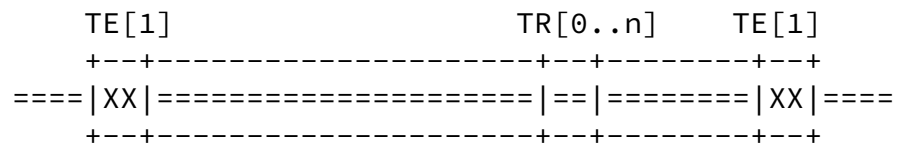


Fig.5 A unified RO supporting ReROT as well as SiROT

As an instance of a unified R0, The attributes of PCH [\[20\]](#) can be summarized as follows:

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TE: Mobile Router (MR), Home Agent (HA), Correspondent Router
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 in
RODM: PCH Piggybacking by HA
ROTT: SiROT+ReROT

[5.](#) Open Issues

? Functional entities involving in R0
?
? Source routing in the inside of nested mobile network
?
? Considerations on R0 in multi-homed mobile networks
?
? Performance / Evaluation Metric for R0
?
TBD

[6.](#) Security Considerations

TBD

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Acknowledgments

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