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Consumer Electronics Requirements for Network Mobility Route Optimization
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Status of this Memo

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Abstract

This document illustrates different deployments of Network Mobility (NEMO) from the consumer electronics perspective. From these deployments, a set of requirements is deduced for Route Optimization

(RO) with NEMO.

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1. Introduction

Network Mobility (NEMO) Basic Support [3] allows a whole network to change its point of attachment while maintaining reachability and session continuity. [4] and [5] investigate the inefficiencies in NEMO Basic Support, and analyze the solution space for Route Optimization (RO) with NEMO from a technical perspective.

This document explores the different deployment scenarios of NEMO from the perspective of consumer electronics. This mainly entails a personal device, called the Personal Mobile Router, as the primary node which a user utilizes to allow the user's other devices to communicate with other nodes in the global Internet. This is detailed in Section 2. From these deployments, a set of requirements is inferred in Section 3.

It is expected for readers to be familiar with terminologies related to mobility in [1] and NEMO related terms defined in [2]. Interested readers may also refer to [6] and [7] for the requirements from the automobile and aviation industries respectively.

2. Deployments of Personal Mobile Router

The Personal Mobile Router is generally envisaged as a mobile communications device, most probably a cellular handphone, with embedded router functionality so as to allow other personal devices (such as MP3 Players, Digital Cameras) to access the global Internet. In such a deployment, it is expected for the Personal Mobile Router to provide all the routing capabilities of the personal area network. This means that one would generally not expect devices (i.e. LFNs) such as digital camera or music players to have routing capabilities. In other words, LFNs are envisaged as simple IPv6 hosts.

However, it is possible for there to be a Local Mobile Node (MNN) in the personal area network. For instance, a laptop or a WLAN-enabled PDA can break off from the personal area network and connect to the Internet on its own. Thus, the device becomes a MIPv6 host, with its home address configured from the Mobile Network Prefix of the personal area network.

This section illustrates three different deployment scenarios with respect to the Personal Mobile Router. First is a simple personal area network where NEMO services is provided by a service provider (such as an telecommunications operator). Next is the deployment where the Personal Mobile Router is docked within a car and serves as an additional Mobile Router for the car network. The last scenario is the case where the Personal Mobile Router obtains a network prefix

not directly from its Internet service providers. Instead, the network prefix is allocated from the user's residence.

2.1. Simple Personal Area Network

The simplest deployment is when the Personal Mobile Router is simply used to provide Internet access to other devices in a user's personal area network. This is the case where the user subscribes to a mobility service provider that allocates a network prefix for the user's personal area network. One example of this is the 3GPP Personal Network Management services [8].

For this scenario, typical communications will be audio/video streaming from a multimedia content server to the music/video player in the user's personal area network. This is a case of communications between a LFN with a CN in the global internet.

```
                                          ----------      ----
                       +-----------------| Internet |----| CN |
                       |                  ----------      ----
                ----------------
               |Mobility Service|
               |    Provider    |
                ----------------
                       |
               /       | 3GPP
               |    --------
               |   | laptop | (MR)
               |    --------
         PAN  <        |
        (NEMO) |       | wifi
               |    -------
               |   |  PDA  | (LFN)
               \    -------
```

Figure 1: Simple PAN deployment

An alternative situation will be communications between devices from two (or more) different personal area networks. For example, two different users may engage in a game with their personal entertainment devices (such as Nintendo or Play Station portables), or share their audio files stored in their music players. This is a case of communications between two LFNs from different NEMO.

```
                          ------------------
                         | Mobility Service |
                         |   Provider (*)   |
                        / ------------------ \
                       /                      \
                      |                        |
                      | 3GPP                   | 3GPP
                   --------                 --------
                  | laptop | (MR)          | laptop | (MR)
                   --------                 --------
                      |                        |
                      | Wired                  | wifi
                      |                        |
                   --------                 --------
                  |Nintendo| (LFN)         |Nintendo| (LFN)
                   --------                 --------
```

(*) - The two MRs may subscribe to the same or different Mobility
      Service Provider(s)

Figure 2: Communications between Two LFNs

An interesting scenario of a Personal Area Network that is beginning to emerge is where the Personal Area Network is composed of a Personal Mobile Router and wearable sensors. Typical deployment [9] would be for a patient who wears wearable sensors that monitor his/her physical conditions (eg., heartbeat, body temperature, blood pressure, etc) periodically and transmit the measurement to a hospital server through the Personal Mobile Router. This is a case of communications between LFNs and a CN wherein the main traffic from the LFN to the CN.

```
                                        ----------      ----------
                              +--------| Internet |----| Hospital | (CN)
                              |         ----------      ----------
                              | GPRS
                         ------------
                        | Cell Phone | (MR)
                         ------------
                              |
                  +-----------+------------+
                  |       Bluetooth        |
              ----------            ---------------
       (LFN) |  Finger  |          | Earphone Body | (LFN)
             | Oximeter |          |  Thermometer  |
              ----------            ---------------
```

Figure 3: Wearable Sensors Network for Medical Monitoring

A more complex use case for Personal Area Network can be described as a dynamic change (scenario) between two different Personal Area Network situations having the same entities. Each entity dynamically changes its role (from, for example, MR to LFN), and, more importantly, the routing task is moved from one entity to another.

Consider a Personal Area Network built from one PDA and one laptop. In the first situation, the laptop is the Mobile Router. It uses its WiMax interface to connect to the Internet and its WiFi interface to offer access to the PDA. Following this, a second situation is formed where the PDA connects its 3G interface to the Internet (becoming the Mobile Router) and gives access to the laptop over WiFi. This is illustrated in Figure 4 below.

```
            ^ to Internet
            |
            | WiMax
         --------                        --------
        | laptop | (MR)                 | laptop | (LFN)
         --------               \        --------
            |               -----\           |
            | wifi          -----/           | wifi
            |                   /            |
         -------                          -------
        |  PDA  | (LFN)                  |  PDA  | (MR)
         -------                          -------
                                             | 3GPP
                                             |
                                             +-------> to Internet
```

Figure 4: Switching of Roles in PAN

Both these situations can exist independently, as there are existing software that is currently supporting these. For example, both Microsoft Windows XP (laptop) and Windows Mobile (PDA) have the ability to connect one interface to Internet and offer access over the other interface.

However, the automatic change between these two situations is not possible without user intervention. The issues around this relate to interface configuration, default route configuration and others. If Mobile IP is used then there are additional issues with respect to pre-established behavior (eg. use or do not use tunnels).

An example application where this support is needed is described next. The scenario above describes the movement of the main routing task from the laptop to the PDA. The routing task (run Mobile IP and NEMO, and hide the LFN from mobility events) can be very consuming

and can compete with user interface events. For example, a user of a laptop and PDA sets up the laptop as MR and PDA as LFN. The user continues editing a document on the laptop. Then, another user arrives with a laptop and needs access. At this point the first user is actually interested in making the PDA to be MR (and not his/her laptop) thus avoiding being disturbed by the more consuming routing task of laptop (routing for two users is doubled).

Depending on the communicating applications, these kinds of scenarios needing dynamic change of role of the entity performing the routing task can be very numerous.

2.2. Personal Mobile Router in a Car

A second scenario involving the Personal Mobile Router is when the user docks the Personal Mobile Router into a car network. This allows the communications devices in the vehicle to use the Personal Mobile Router to access information from the Internet. It also allows the personal devices in the personal area network to use the Mobile Router in the vehicle network to communicate with correspondent nodes on the Internet. In other words, the two mobile networks (personal area network and vehicle network) merges to form a multihomed network.

There are two possible configurations that could arise. The first possible configuration is where the car sensors and automotive devices are connected to Car Mobile Router using a wired medium (such as the Controller Area Network, etc), and the personal devices are connected to the Personal Mobile Router using a wireless medium (such as the Bluetooth or Ultra Wide Band). The Personal Mobile Router is connected to the Car Mobile Router via a docking mechanism installed in the car. This is illustrated in Figure 5 below.

```
                         WiMAX           3G
        Car Sensors        |               |     Personal Devices
    & Automobile Devices   |               |  (Eg. iPod, PSP, Lumix)
        _       _          |               |          _     _
       |_|     |_|      --------        --------     |_|   |_|
        |       |      |  Car   |      |Personal|     |     |
     --+--+-----+--+---| Mobile |======| Mobile |-----+--+--+--
      _   |   _   |    | Router | Dock | Router |    _   |
     |_|--+  |_|--+     --------        --------    |_|--+

     <----- CAR NEMO ----->               <------- PAN ------>
```

Figure 5: Separate Links in Merged NEMO

In such a merged network, the vehicle network devices and the

personal area network devices will continue to use their own original network prefixes to communicate with external nodes. Hence, one way to view this is to treat it as if the two Mobile Routers attaches to each other, and uses each other as an additional access router. This implies that the a communication between a MNN and a correspondent node may go through two Mobile Routers (e.g. the communication from the car navigation device to a traffic condition server passes through first the Mobile Router of the car, and then the Personal Mobile Router). Hence, this can be viewed as a case of a nested NEMO.

A second possibility is that the car network and the personal area network fused into a single network with two mobile routers. One way this can happen is when the two networks use the same wireless technology such as Bluetooth or Wireless Universal Serial Bus as the interconnection medium. This is shown in Figure 6 below. This is a typical NEMO with multiple mobile routers and prefixes [10]. The car devices are free to configure an address from the Mobile Network Prefix of the Personal Mobile Router to communicate with other correspondent nodes in the Internet (such as a realtime traffic monitoring server). Similarly, the personal devices are free to configure an address from the Mobile Network Prefix of the Car Mobile Router to communicate with other correspondent nodes in the Internet (such as a You-Tube video server).

```
                        WiMAX            3G
                          |               |
                       --------        --------
                      |  Car   |      |Personal|
                      | Mobile |      | Mobile |
                      | Router |      | Router |
           _       _   --------        --------   _     _
          |_|     |_|     |               |      |_|   |_|
           |       |      |               |       |     |
         --+--+----+--+---+---------------+-------+--+--+--
          _   |   _   |                          _   |
         |_|--+  |_|--+                         |_|--+

          Car Sensors                      Personal Devices
      & Automobile Devices              (Eg. iPod, PSP, Lumix)

           <------- Merged Into a Single NEMO --------->
```

Figure 6: A Single Link in Merged NEMO

When the car network and the personal area network fused into a single network, LFNs in this single network can communicate with each other. For example, a sensor which was a LFN of the personal area

network senses the body temperature of the driver and send this information to the activator which was a LFN of the car network to make the car environment comfortable for the driver. Since the car network and the personal area network became a single network, this communication is a case of intra-NEMO communication.

2.3. Residence Home Network

This scenario is a special deployment as it differs from the usual subscription model that is more commonly used. Basically, in this scenario, the home network of the Personal Mobile Router (as far as NEMO is concerned) is literally the "home" -- i.e. the residence of the user. It is envisioned that the user deploys a residence-wide network with a set-top box serving as the gateway. This set-top box is connected to the Internet via broadband connection (cable or ADSL) and obtains an IPv6 prefix from the ISP. Part of the IPv6 prefix obtained is then assigned as the prefix for the user's personal are network (i.e. the Mobile Network Prefix for the personal area network). The set-top box is thus configured as the home agent of the Personal Mobile Router.

Typically, the devices in the personal area network (i.e. LFNs) would communicate mostly with other devices in the residence network (e.g. personal video player accessing movie stored in a digital video recorder in the residence). In such situation, route optimization is redundant. However, there exist situations where multiple personal area networks (each belonging to different family members) belong to the same residence network. Devices from these different personal area networks may communicate with each other often enough. In the latter situation, it is a case of two MNNs from different NEMO communicating with each other.

3. Characteristics of Route Optimization for Consumer Electronics

Not all communications involving personal area network require route optimization. There are, however, two particular use cases where route optimization is highly preferable. The first use case is when devices in a personal area network are used for real time interactive applications which are sensitive to round trip delays. Examples include voice-over-IP communications and multiplayer gaming sessions. This usually entails communications between two devices from two different personal area network, as illustrated in Section 2.1 and Section 2.3. In such cases, there might be two different home agents involved (one for each NEMO), hence making the improvement in delay reduction of route optimization more significant. The second use case is when the home network is congested, or otherwise bandwidth-limited. One example is the residence home network as described in

Section 2.3. Most broadband residence access are asymmetrical (i.e. the uplink bandwidth is much smaller than the downlink bandwidth), making it unsuitable for the home agent (e.g. set-top box) to forward large amount of packets to Personal Mobile Routers.

Where route optimization is highly preferable, we can infer the following requirements (denoted by "Req") in Section 3.1 and desirable features (denoted by "Des") in Section 3.2 from the deployment scenarios described in Section 2.

3.1. Required Characteristics

3.1.1. Req1: Unmodified LFNs

A route optimization solution MUST operate even when LFNs are unmodified

Rationale:

Devices in the personal area network are envisaged as simple IPv6 node. The Personal Mobile Router is expected to provide route optimization services for any consumer electronic devices that connect to its personal area network. Thus, it is expected for LFNs to remain unmodified and unaware of mobile network's movement for route optimizations.

3.1.2. Req2: Low Processing Load

A route optimization solution MUST NOT increase the processing load of the MR significantly

Rationale:

The Personal Mobile Router is a small mobile device (e.g. handphone) that is limited in battery power. Hence, any route optimization solution should not significantly increases the processing load of the MR.

Processing load here is used to generally refer to the computation load, signaling load, and memory storage requirements for establishing and managing a route optimization

A quantitative requirement on what is the acceptable increase in processing load is impossible to be specified; however, one possibility is to use the current Mobile IPv6 Route Optimization as a benchmark reference. A processing load increase for route optimization of a session is acceptable if it is comparable to the

amount of additional processing for Mobile IPv6 Route Optimization (i.e. the CoTI/CoT and HoTI/HoT signaling and adding of home address destination option).

3.1.3. Req3: Security

A route optimization solution MUST NOT expose the mobile network to additional security risk

Rationale:

Security is a prime consideration in the deployment of Personal Mobile Router, since the personal area network may store private information. In general, a personal area network would not allow external devices to attach to the mobile network, hence the Personal Mobile Router will the most important gateway in which security of the personal area network is enforced. As such, any route optimization solution should not expose the Personal Mobile Router to additional risk as compared to NEMO Basic Support.

Particularly, it must not be possible for other nodes to claim ownership of the Mobile Network Prefix (in entirety or in parts). Additionally, denial-of service attacks on the Personal Mobile Router (e.g. by forcing the Personal Mobile Router to send a huge amount of signaling packets or to maintain a large number of signaling states) must not be possible.

3.1.4. Req4: Protocol Harmony

A route optimization solution MUST NOT break or prevent the use of existing protocols

Rationale:

As LFNs are assumed to be unmodified (see Req1), the communications protocols used by them must not be modified as well. A route optimization solution used by the Personal Mobile Router must not cause any communications between the LFN and its correspondent node to stop working. In other words, LFNs should be able to continue to use any protocols that they are able to use without route optimization. This includes IPSec and other IP layer signaling protocols.

3.2. Desired Characteristics

3.2.1. Des1: MR-to-MR Route Optimization

As seen in Section 2, most of the communications we envisaged are in the form of a MNN communicating with another MNN in different personal area networks. As we do not expect MNNs to be involved in route optimization signaling, a suitable route optimization would likely be between the two MRs. This way, correspondent nodes would not be impacted.

3.2.2. Des2: Nested-NEMO Route Optimization

In Section 2.2, a scenario is illustrated where the Personal Mobile Router is attaching to the car mobile router for Internet access (and vice versa). If the car mobile router performs route optimization for its network, then the Personal Mobile Router can run a separate route optimization session to achieve fully-optimized route. Alternatively, it is also possible for the Personal Mobile Router to support some mechanism that achieve nested-NEMO route optimization.

This desired feature can be generally extended to other forms of nesting where the user brings a PAN into a larger mobile network, such as in a plane, a train, or a ship. It is desired that a route optimization solution should yield a fully optimized route regardless of whether the Mobile Router of the larger mobile network performs route optimization or not.

3.2.3. Des3: Intra-NEMO Route Optimization

In Section 2.2, a scenario is illustrated where nodes in a the car network and nodes in the personal area network communicates with each other. It is desirable that any route optimization solution would work for intra-NEMO communications as well. It will be even preferable if such intra-NEMO route optimizations can be achieved without sending signalling messages out of the mobile network.

3.2.4. Des4: Separability

As route optimization would inevitably increase the processing load of the Personal Mobile Router, it would be desired that the user be able to select route optimization for some traffic and use the bi-directional tunnel with home agent for other traffic. In other words, a route optimization solution should preferably not be a "all-or-nothing" mechanism. It should be possible to have both route optimized flows and non-optimized sessions simultaneously.

3.2.5. Des5: Multihoming

As described in Section 2.1, it is likely for a PAN to be equipped with multiple access technologies. Thus, it is desirable that a route optimization solution be able to make use of multiple access networks when available. It is also desirable to have this feature regardless of whether all the available access to external networks reside in one or multiple devices. For instance, in Section 2.2, a scenario is described where there are two Mobile Routers in the merged network.

4. IANA Considerations

This is an informational document and does not require any IANA action.

5. Security Considerations

Security is a prime consideration in the deployment of Personal Mobile Router. The requirements for security involving the Personal Mobile Router are discussed in Section 3.

6. References

6.1. Normative Reference

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Appendix A. Change Log

o draft-ng-nemo-ro-req-02:

  * Added "Protocol Harmony" as requirement

  * Added "Separability" and "Multihoming" as desired feature

  * Elaborated more on some of the explanations of requirements

o draft-ng-nemo-ro-req-01:

  * Expanded Section 2.2 to include different possible configurations

  * New scenarios in Section 2.1 and Section 2.2

  * Organized Section 3 to have one-liner requirements, followed by the explanation to give a more concise presentation

  * Added Jun, Eun Kyoung and Alexandru as co-authors

  * Various other editorial fixes

o draft-ng-nemo-ro-req-00:

* Initial version.

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