Distributed mobility management for Future Internet

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Core network: Convergence

- Core network: converge (cellular and Internet – no more IPv4 blocks available)
- Access networks: diverse
- Devices: multiple interfaces, multiple functions, mobile
- Traffic from Wireless device grows 3 times faster than (exceeding soon) that of wireline devices
- Internet: lack native support for mobility, multi-homing, etc.
Wireless access network: Cellular

1 Gbps
(4G) LTE-Advanced >1Gbps; IEEE802.16m, OFDMA
LTE 326/86 Mbps
HSPA+ 84/23 Mbps
(3.5G) HSPA 14.4/5.76 Mbps, EV-DO Rev B
(3G) UMTS: WCDMA; CDMA2000 1x 2 Mbps
10 Mbps
EDGE 384 kbps
100 kbps
(2.5G) GPRS 14.4 kbps
10 kbps
(2G) GSM 9.6 kbps

Extend through handoff

1 m 10 m 100 m
1 km 10 km
100 km

Wireless broadband network: 802 wireless family

802.11a/b/g/n WLAN <11, 54, 300 Mbps
802.16 10–66GHz
802.16 2–11GHz WiMax
802.15 Bluetooth 700kbps

Internet

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Internet: ID-Locator split problem

♦ IP address (of interface) changes when routing changes. Transport session does not survive under IP changes.
♦ ID (of host): Used for session, rarely changes.
♦ Locator (IP address): Used for network routing.
♦ Mapping system (control plane): maps ID with a set of locators (IP addr)
What is the ID/Locator Split Protocol?

- **Client based / Client-network changes**
  - Architectural change to the TCP/IP stack
  - A new layer between IP and transport
  - Session between Host IDs not affected by locator changes

**Major protocols/proposals:**
- HIP (Ericsson/HIIT)
- i3 (UC Berkeley)
- Clean slate design (Stanford)
- Internet 3.0 (WashU)

Network based: No change to client stack
- Locator = globally routable IP addr in backbone/Internet only
- ID = edge network IP addr; session not affected by locator changes in Internet.

**Major protocols:**
- LISP (Cisco);
- APT (UCLA)
- HIP (Ericsson/HIIT)
- I3 (UC Berkeley)
- Clean slate design (Stanford)
- Internet 3.0 (WashU)

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ID-Locator Split families

**Protocol stack (e.g. HIP)**

![Diagram showing protocol stack with ID and Locator layers]

**Core-edge separation: tunneling (e.g. LISP) or translation**

![Diagram showing core-edge separation with tunneling or translation]

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Mobile IP

![Diagram showing mobile IP with home network, visited network, mobile node, and correspondent node]

**Session Identifier**
- Locator (CoA)

**Transport**
- IP address before move
- Current IP address

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Proxy Mobile IP

![Diagram showing proxy mobile IP with MAG, LMA, MN, and CN]

**MAG: Mobile access gateway**
**LMA: Local mobility anchor**
Host-based versus Network-based mobility management

Host-based mobility management (HoA: P1::mn, CoA: P3::mn)

Host-based mobility anchors

Network-based mobility management (HoA: P1::mn, CoA: P3::ar)

Network-based mobility anchors

Distributed mobility anchors

♦ Distributed versus centralized mobility anchors
♦ Splitting control and data planes: Architecture
♦ Unified formulation of Internet mobility
♦ DMM Route optimization mechanism example

Centralized mobility anchors

♦ Current mobile networks are hierarchical, and existing mobility solutions are deployed with centralized mobility anchoring
♦ E.g. HA in MIPv6/DSMIPv6, LMA in PMIPv6, GGSN in 3GPP

GPRS/UMTS

SAE

MIP

PMIP

GGSN

P-GW

HA

LMA

SGSN

SGSN

S-GW

S-GW

FA

FA

MAG

MAG

• Network: hierarchical versus flattened
• Mobility management: centralized versus distributed
Proxy mobile IP (PMIP) with triangle routing problem

- Packets between MN and CN need to tunnel between MAG and LMA, even when MN is far from home network but is close to CN

LMA: Local mobility anchor
= Home agent (HA) + PMIP function
MN: mobile node
CN: correspondent node

Problem statement PS1: Non-optimal routes

- (1) Routing via a centralized anchor often results in a longer route.

PS1: Non-optimal routes (continued)

- The problem is manifested, for example, when accessing a local server or servers of a Content Delivery Network (CDN).

PS2: Divergence from other evolutionary trends in network architectures

- Centralized mobility management can become non-optimal with a flat network architecture.
- In contrast, distributed mobility management can support both hierarchical network and more flattened network.
PS3: Low scalability of centralized tunnel management and mobility context maintenance

- Setting up tunnels through a central anchor and maintaining mobility context for each MN therein requires more resources in a centralized design, thus reducing scalability. Distributing the tunnel maintenance function and the mobility context maintenance function among different network entities can increase scalability.

PS4: Single point of failure and attack

- Centralized anchoring may be more vulnerable to single points of failures and attacks than a distributed system. The impact of a successful attack on a system with centralized mobility management can be far greater as well.

PS5: Wasting resources to provide mobility support to nodes that do not need such support

- IP mobility support is not always required, and not every parameter of mobility context is always used. For example, some applications do not need a stable IP address during a handover to maintain IP session continuity. Sometimes, the entire application session runs while the terminal does not change the point of attachment.

PS6 (related): Mobility signaling overhead with peer-to-peer communication

- Wasting resources when mobility signaling (e.g., maintenance of the tunnel, keep alive, etc.) is not turned off for peer-to-peer communication.
PS6 (related): Mobility signaling overhead with peer-to-peer communication (continued)

- Peer-to-peer communications have particular traffic patterns that often do not benefit from mobility support from the network. Thus, the associated mobility support signaling (e.g., maintenance of the tunnel, keep alives, etc.) wastes network resources for no application gain. In such a case, it is better to enable mobility support selectively.

PS7 (related): Complicated deployment with too many MIP variants and extensions

- Deployment is complicated with many variants and extensions of MIP. When introducing new functions which may add to the complicity, existing solutions are more vulnerable to break.

- Variants: MIP, PMIP, HMIP, FMIP, DSMIP, …, etc.

Distributed mobility anchors

- Distributed versus centralized mobility anchors
- Splitting control and data planes: Architecture
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Distributed mobility anchors-Architecture

- LMA functions: mobility routing + location management + HoA allocation.

LM: Location management (control plane)
MR: Mobility routing (data plane)
Distributed mobility anchors - Architecture

MR: Mobility routing function (data plane)
- Network-based: MR in every network, at GW which may move down to AR in flat net
- Host-based: MR at host

Location Management function (control plane)
- LM is supported by distributed database

Unified formulation of Internet mobility standards

3 Basic Internet Functions
- 1. The Internet allocates IPv6 network prefixes or IPv4 addresses to a host.
- 2. The Internet manages information needed for routing by maintaining a database (DNS) and exchanging routing information between routers.
- 3. Router forwards packets using appropriate information in the routing table

3 Basic Mobility Management Functions
- 1. Session identifier allocation
- 2. Location management (LM)
- 3. Mobility routing (MR)

Session continuity

- Session may continue when EID (inner IP address) does not change.

Uses EID
- Network (inner IP address)

Uses RLOC
- Network (outer IP address)
- Map-and-Encap

Process
- Socket = IP addr + Port #
Host-based versus Network-based mobility management

Host-based mobility management (HoA: P1::mn, CoA: P3::mn)

HoA -> HoA -> HoA -> HoA
CN -> MR -> CoA
MN (P1::mn)
Mobility client

Network-based mobility management (HoA: P1::mn, CoA: P3::ar)

HoA -> HoA -> HoA -> HoA
CN -> MR -> CoA
AR (P3::ar)
Mobility client

Mobility Management Framework

Logical Functions:
1. HoA allocation
2. LM: Location management (control plane)
3. MR: Mobility routing (data plane)

♦ Architecture: Configure the logical functions
♦ Protocol: Messages
♦ Construct one step at a time: MIPv6, PMIPv6, HMIPv6, Distributing mobility anchors, dynamic mobility, DMM

Existing protocol: MIPv6

Logical Functions:
HoA allocation; LM: Location management (control plane); MR: Mobility routing (data plane); LU: location update

Net1 (P11::mn11, P31::mn11)
LM1
Allocate P11::/64
MN11 (P11::mn11, HoA11)
Move13
MN11+MC
P11::mn11 (HoA11)
P31::mn11 (IP31)
CN21
P21::cn21 (IP21)

Existing protocol: PMIPv6

Logical Functions:
HoA allocation; LM: Location management (control plane); MR: Mobility routing (data plane); LU: location update

Net1 (P12::mn12, P32::ar32)
LM1
Allocate P12::/64
AR32+MC
P32::ar32 (proxy IP32)
Move13
P12::mn12 (HoA12)
P21::mn12 (IP21)
CN21
P21::cn21 (IP21)
MIPv6/PMIPv6

Logical Functions:
HoA allocation; LM: Location management (control plane); MR: Mobility routing (data plane); LU: location update

Allocated:
P1::/64
P2::/64
P3::/64

Hierarchical

Logical Functions:
HoA allocation; LM: Location management (control plane); MR: Mobility routing (data plane); LU: location update

Deploying in all networks

Selective mobility management without ongoing application requiring session continuity
Selective mobility management
with ongoing application requiring session continuity

(P11::mn11, P3::mr3)
(P11::mn12, P3::mr3)

(P12::mn12, P3::mr3)

Logical Functions:
HoA allocation; LM: Location management (control plane); MR: Mobility routing (data plane); LU: location update

DMM

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that I may serve others. H Anthony Chan
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DMM Example

Logical Functions:
- HoA allocation; LM: Location management (control plane); MR: Mobility routing (data plane); LU: location update

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DMM Example

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Thank you

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