Hybrid Distributed Mobility Management Scheme for Next-Generation Wireless Networks

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Outline

1 All-IP Mobility Management Schemes
   - Quick Overview
   - Motivation

2 System Model
   - Centralized Mobility Management (CMM)
   - Distributed Mobility Management (DMM)
   - Proposed Hybrid-DMM scheme

3 Numerical Investigations

4 Concluding remarks
Centralized Mobility Support (CMM)

- Centralized entities handle the mobility support
- Host-based solutions (i.e. MIPv4\(^1\), HMIPv6\(^2\))
- Network-based solutions (i.e. PMIPv6\(^3\))

Disadvantages

- Suboptimal routing
- MAs possibly points of congestion → latency
- Reliability (failure of MA → system failure)
- Scalability issues
- No dynamic mobility support

\(^1\)http://www.ietf.org/rfc/rfc5944.txt
\(^2\)http://www.ietf.org/rfc/rfc5380.txt
\(^3\)http://www.ietf.org/rfc/rfc5213.txt
Centralized Mobility Support (CMM)

HMIPv6 overview

Figure 1: HMIPv6 architecture overview
Centralized Mobility Support (CMM)

MIPv6 and PMIPv6 overview

Figure 2: (a) MIPv6 and (b) PMIPv6 architectures overview
Distributed Mobility Management (DMM)\(^1\)

- Mobility function at the edge of core network
- Access routers become mobility anchors
- Flows are forwarded from old to the new AR
- Each new flow gets routed directly to the new AR
- Host or network based
- Fully or partially distributed solutions

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\(^1\)http://datatracker.ietf.org/doc/draft-ietf-dmm-best-practices-gap-analysis
Main challenges

- Is the decentralization of the mobility function always better?
- How does the topology of the core affect the performance of the mobility support scheme?
- How do the CMM and the DMM compare in different scenarios?
- Can a solution between those two approaches outperform them?

Targets of this paper:

- Optimal MAs configuration in CMM scenario
- DMM modelling
- Comparison of CMM & DMM
- Proposal of a Hybrid-DMM
- Evaluation of proposal
Centralized Mobility Scheme

Optimization Framework

Assumptions
- Centralized architecture
- L available MAs
- K flows from GW to ARs
- Tree-like topology

Aim
- Minimize the total routing and mobility cost by calculating the optimal:
  - number of MAs
  - location of MAs
  - selection of MAs by ARs

Inputs
- Graph $G = (V, E)$
- Flows $k$ and demands $d$
- Set of available paths $p_{km}$
- Graph $G = (V, E)$
- Mobility matrices $H_{K \times J}$ and $W_{K \times J \times J}$, where $J$ is the number of ARs
Centralized Mobility Management (CMM)

Optimization Framework

The total routing cost \( \Xi \) can be written as follows:

\[
\Xi = \sum_{k \in K} \sum_{m \in J} d_k p_{km} x_{km}
\]  (1)

And the total mobility cost \( \Psi \) can be written as:

\[
\Psi = \sum_{k \in K} \sum_{m \in J} \sum_{j \in T} \left\{ h_{kj} \left( d_k x_{jm} p_{jm} + Z_{kj} (x_{jm} - G_{kjm}) \right) \right. \\
+ \left. \sum_{l \in T} w_{kjl} \left( d_k x_{lm} p_{lm} + Z_{jl} (x_{lm} - G_{jlm}) \right) \right\}
\]  (2)

The aim is to minimize the total cost \( T = \Xi + \Psi \)
Distributed Mobility Management (DMM)

System Model

- Fully distributed approach
- Network-based solution
- Every AR is a MA
- Flows start from a single source node and are destined to the ARs
Hybrid-DMM
Architectural overview

Figure 4: (a) CMM, (b) DMM, and (c) Hybrid-DMM scheme
Hybrid-DMM
Proposed Mobility Management Scheme

Algorithm 1 Hybrid-DMM

1: for \( k = 1 \) to \( K \) do
2: \hspace{1em} Calculate the cost of every flow using DMM scheme
3: \hspace{1em} if \( T \geq \gamma \) then
4: \hspace{2em} Index flow \( k \) in a group \( A \)
5: \hspace{1em} end if
6: end for
7: Solve the proposed Integer Programming Algorithm \( \forall k \in A \)
8: Anchor those flows to the optimal MAs from step 7
9: Support the rest of the flows to the edge routers using DMM
Numerical Results
CMM-DMM Comparison

Figure 5: Total cost for different topologies for CMM and DMM scheme

Figure 6: Total cost for different end-user mobility case for CMM and DMM scheme
Numerical Results

DMM performance (per access router analysis)

Figure 7: Total cost for each AR domain in DMM scheme (the set threshold $\gamma$ has been set at 87%)

- 511 total nodes in network
- 256 access routers
- Specific flows have 30% more than the network average cost
- These domains affect delay sensitive flows
- Supporting them with hierarchically higher located MAs can be more efficient
Numerical Results
Performance of the proposed scheme

- Handling of the aforementioned areas by H-DMM improves the cost
- This solves the problem of topology dependence
- Achieved gain for the supported flows ranges from 15% to 20%

Figure 8: Total cost of flows supported by DMM and Hybrid-DMM

Concluding remarks

Conclusions

- The network topology can affect the performance of the mobility management scheme

- Although DMM performs in general better than CMM there are areas where distribution is not the solution

- Handling specific AR domains with MAs located higher across the network is more efficient

- Very good performance of the proposed H-DMM, concerning the supported flows (the gain ranges from 15% to 20%)

✓ The work is now moving to take into account optimized mobility in virtualized mobile networks
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\(^1\)http://mitn-crossfire.eu/
Thank you for your time

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