



Mobile Ad Hoc Networks as Access Networks for the Internet and Mobility Management

by **Quan Le Trung & Gabriele Kotsis** (EuroView2007, Jul.23-24 2007)
{quanle, gk}@tk.uni-linz.ac.at

Johannes Kepler University Linz, Department of Telecooperation
EuroFGI Community : **Participant No. 4 (TK/JKU)**
Sponsors : **ÖAD (Austrian Exchange Service)**
EuroNGI/FGI
TK/JKU

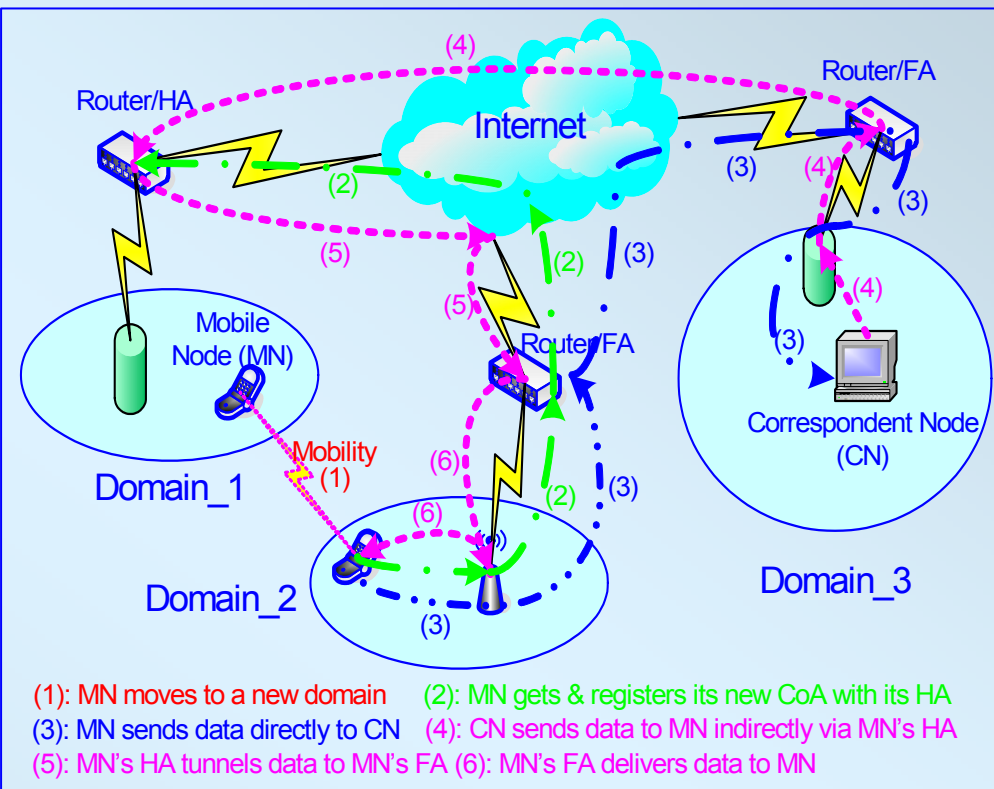
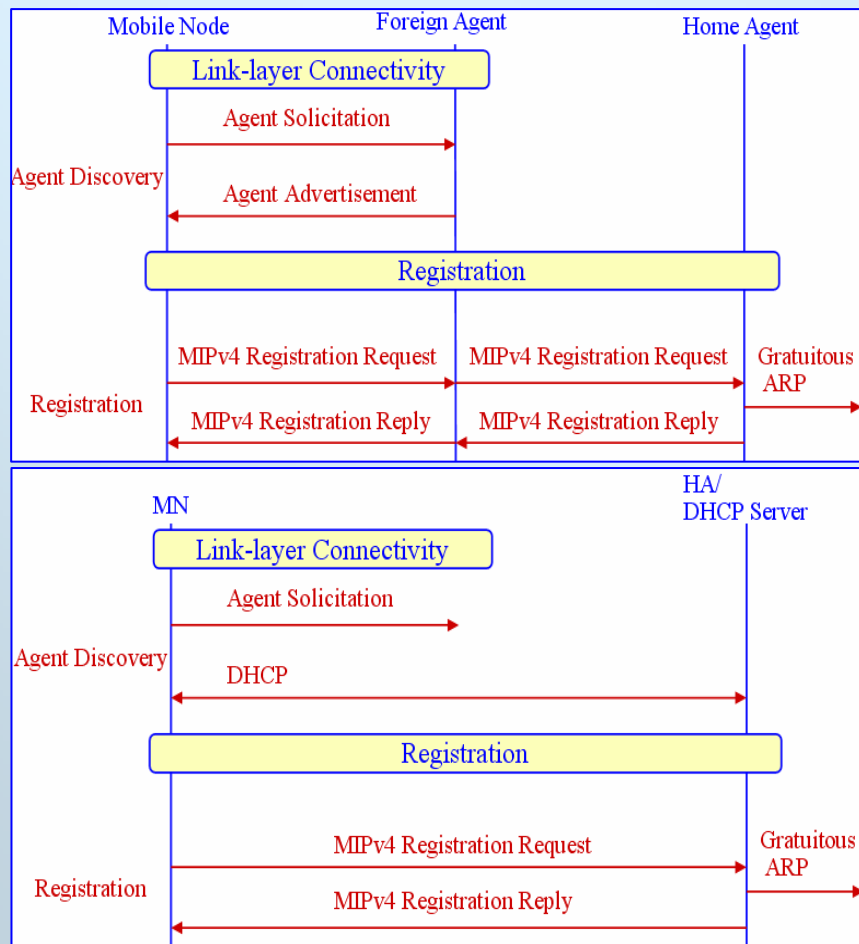


Contents

- A Review on existing mechanisms in Internet Mobility Management
 - IP Mobility Management
 - IP Mobility Management over WLAN (1-Hop)
 - IP Mobility Management over MANET (Multi-Hop)
- Needing functions on Internet connectivity for MANETs
- Discovering problems on Internet gateway forwarding strategies for MANETs & Solutions
- A new Internet gateway selection metric
 - Shortest Euclidean distance
 - Load-balancing for traffic in/out the Internet from/to MANET
 - Load-balancing for Internal MANET traffic

Review IP Mobility Management [MIPv4] (1/5)

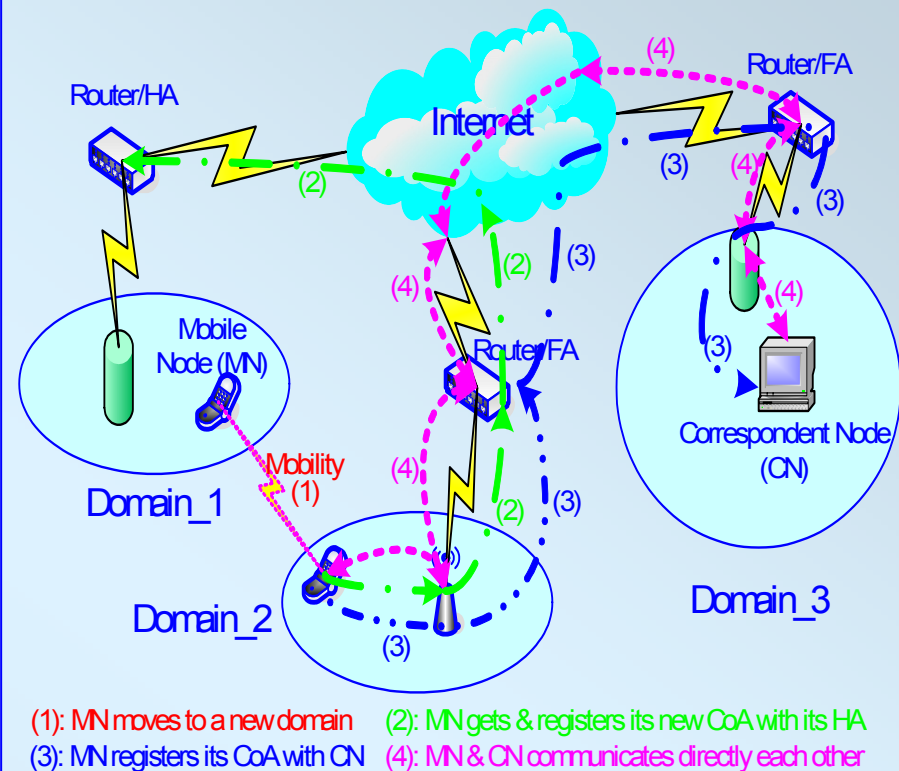
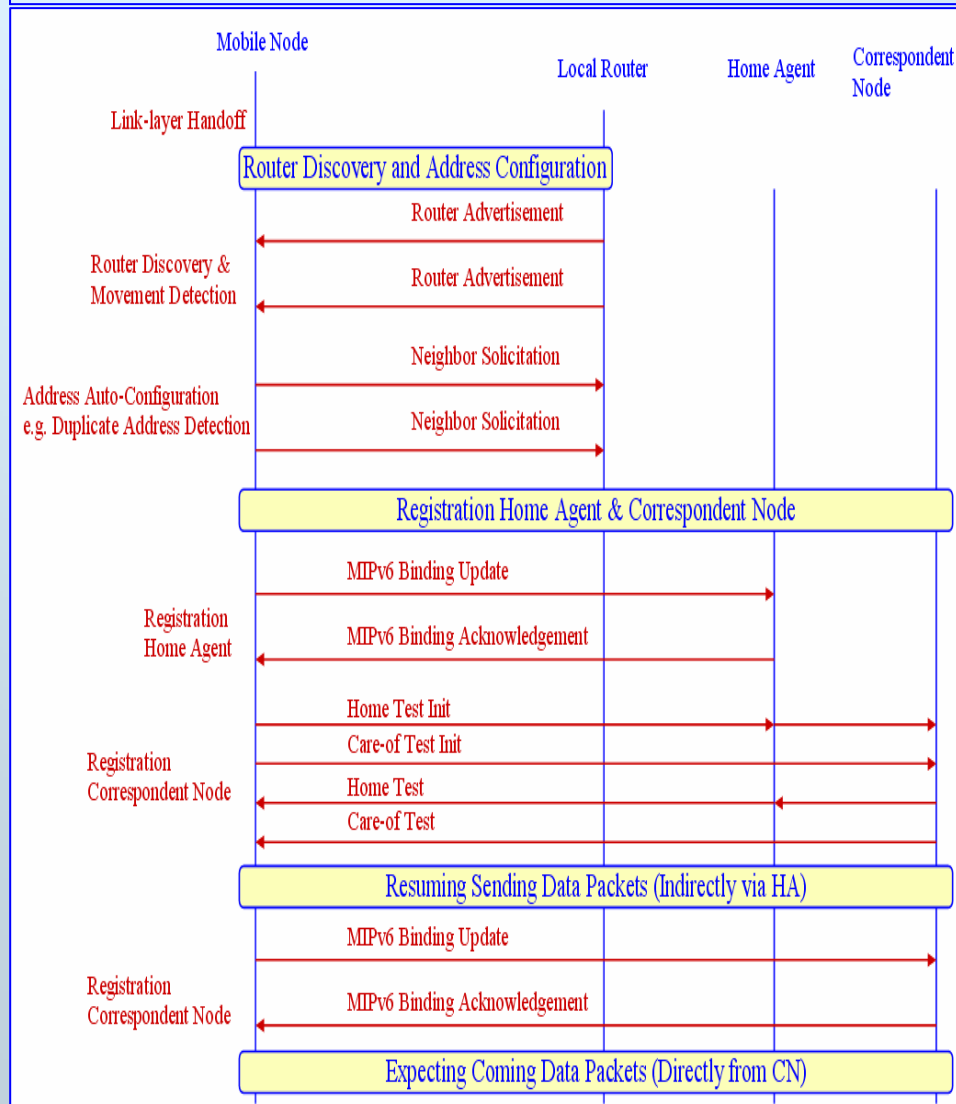
Foreign Agent Care-of Address



C. Perkins, "IP Mobility Support for IPv4," Internet Draft draft-ietf-mip4-rfc3344bis-03.txt, Mar.2007
 IETF Mobile IP WG, "Mobility for IPv4 (mip4) Charter,"
<http://www.ietf.org/html.charters/mip4-charter.html>.

Co-Located Care-of Address

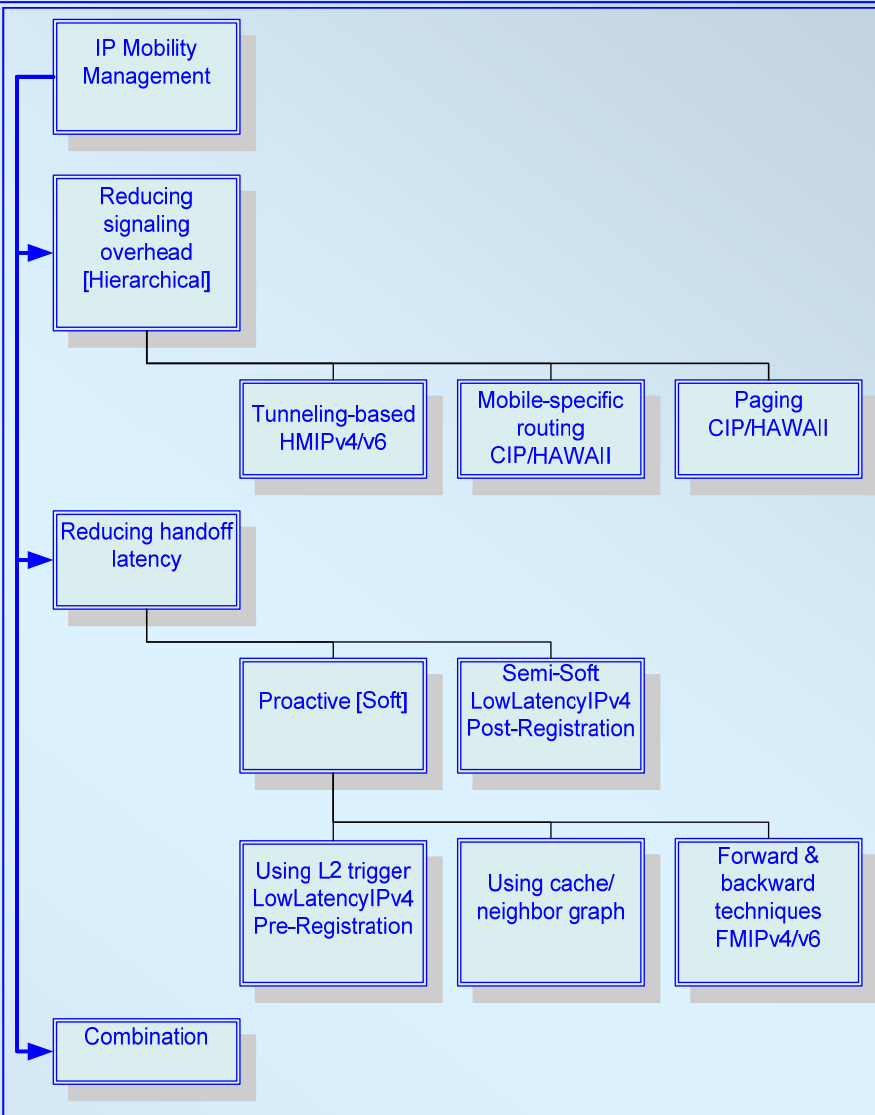
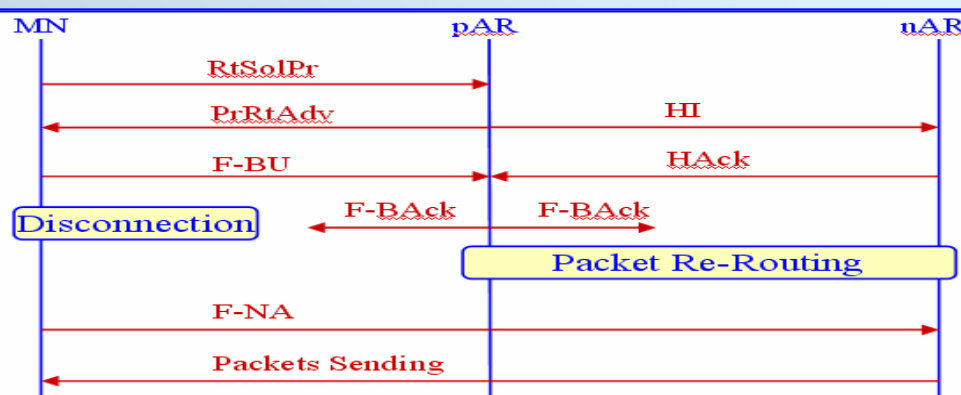
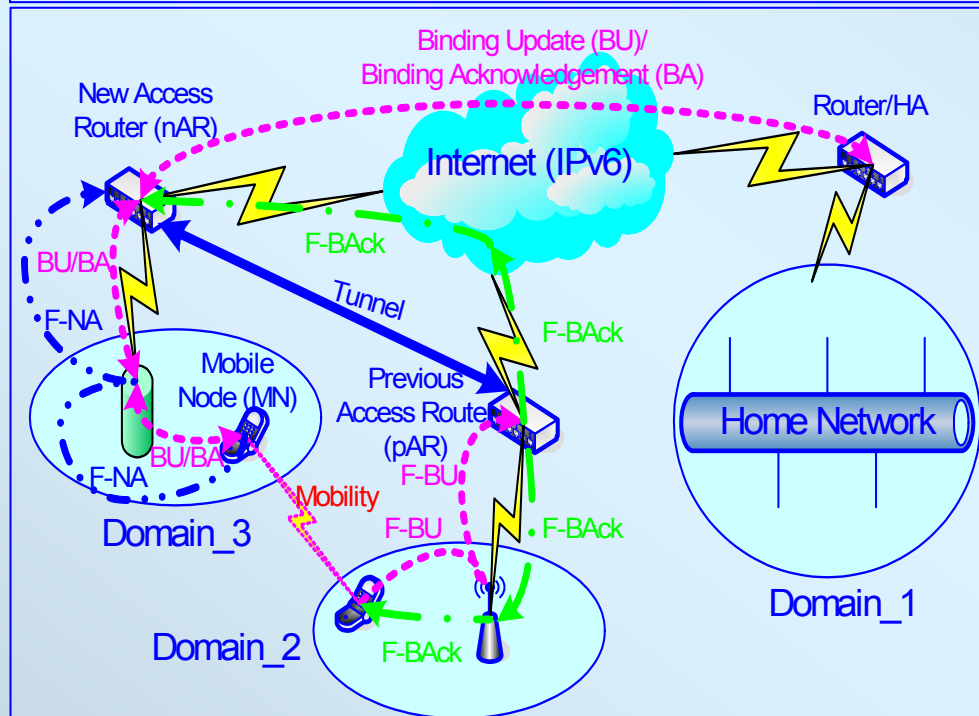
Review IP Mobility Management [MIPv6] (2/5)



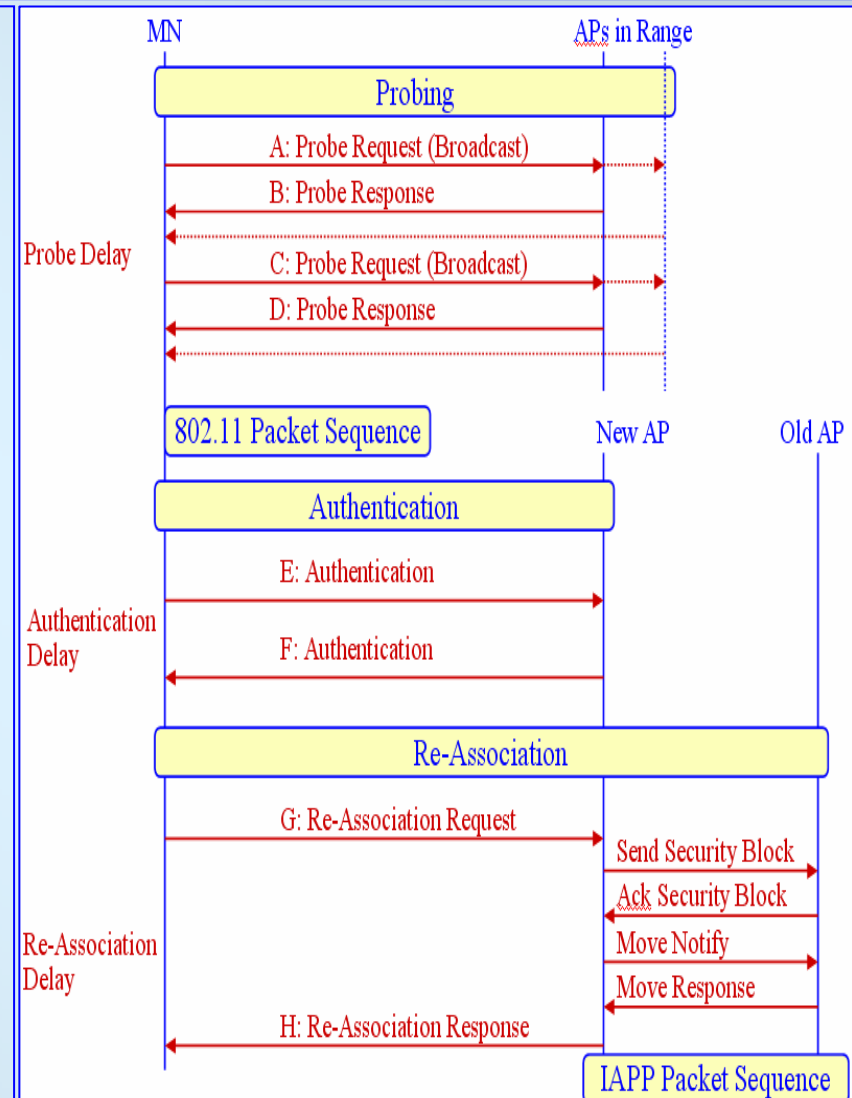
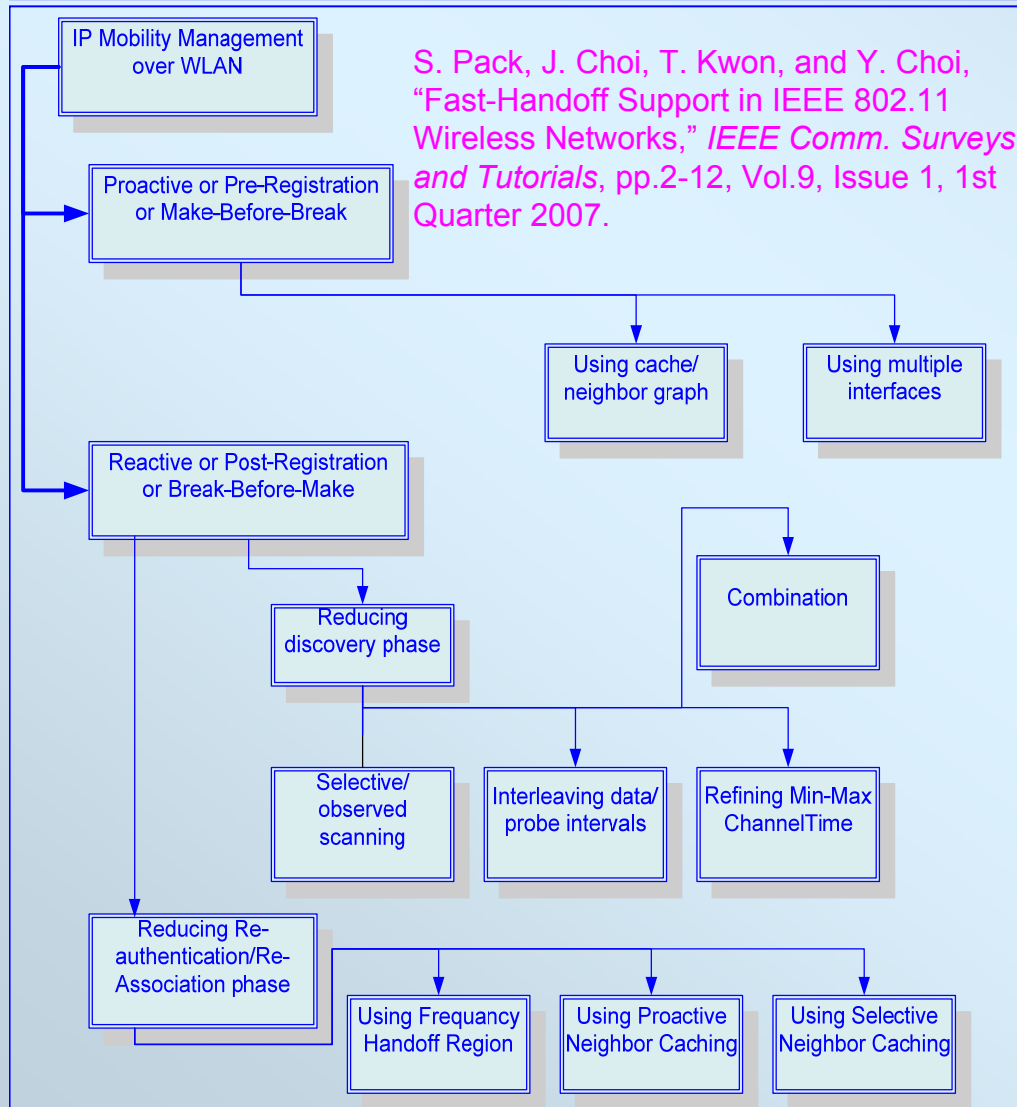
D. Johnson, C. Perkins, and J. Arkko, "Mobility Support in IPv6," rfc3775.txt, Jun.2004.

IETF Mobile IPv6 WG, "Mobility for IPv6 (mipv6) Charter," <http://www.ietf.org/html.charters/mip6-charter.html>.

Review IP Mobility Management [FMIPv6] (3/5)



Review IP Mobility Management over WLAN (4/5)

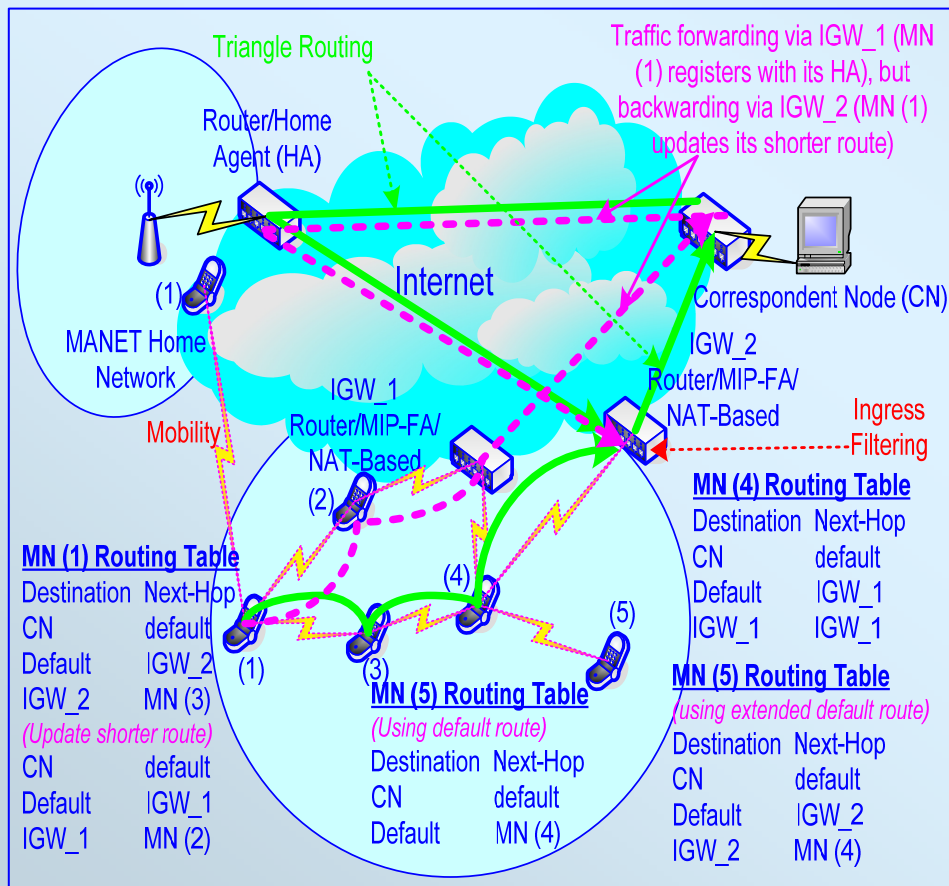


Review IP Mobility Management over MANET (5/5)

TABLE IX. → COMPARISON BETWEEN DIFFERENT MECHANISMS FOR MANET INTERNET ACCESS AND MOBILITY MANAGEMENT [1]

Index	Mechanism	Location determination	IGW-discovery	IGW-selection-metrics	IGW-forwarding	Addressing	Handoff style
1	MIPv6+ AODVv6 [66][210][211]	Network prefix	Proactive & reactive	Not specified, implicitly shortest-hop-count	Default route & AODVv6 [13]	Deriving from IPv6 stateless auto-configuration	Both
2	MIPMANET [73]	Flooding RREQ	Proactive	Shortest hop-count	Half-tunneling & AODV [12]	Not specified, but Home Address must be IP global unicast	Route optimization-based
3	MIP+DSR [238]	Using IGW	Reactive	Not specified, implicitly shortest-hop-count	Source routing & DSR [14]	Home Address must be IP global unicast	Not specified, implicitly route optimization-based
4	MIP+OLSR [173]	Using routing tables	Proactive	Not specified, implicitly shortest-hop-count	Default route & OLSR [18]	Not specified	Forced (when a prefix change)
5	MEWLANA TD/RD [187]	Using routing table (DSDV) or TBR Tree	Proactive	Shortest hop-count	Default route & DSDV or TBR	Not specified	Forced (when a route change or node leave)
6	Two-tier MANET [215]	Using routing tables	Reactive	Load-balancing	Tunneling uses extra UDP/IP header & DSDV	Private address & NAT, allocating using DHCP	Not specified, implicitly route optimization-based
7	Hybrid MANET [172]	Using routing tables	Reactive	Hybrid: Euclidean distance & load-balancing	Default route & DSDV [19]	Not specified	Forced (using automatic mode-detection and switching)
8	WLAN & MANET [170]	Using routing tables	Proactive	Not specified, implicitly shortest-hop-count	Default route & OLSR [18]	IPv6 stateless auto-configuration	Forced (using automatic mode-detection and switching)

Discovered Problems on Internet Gateway Forwarding in MANET

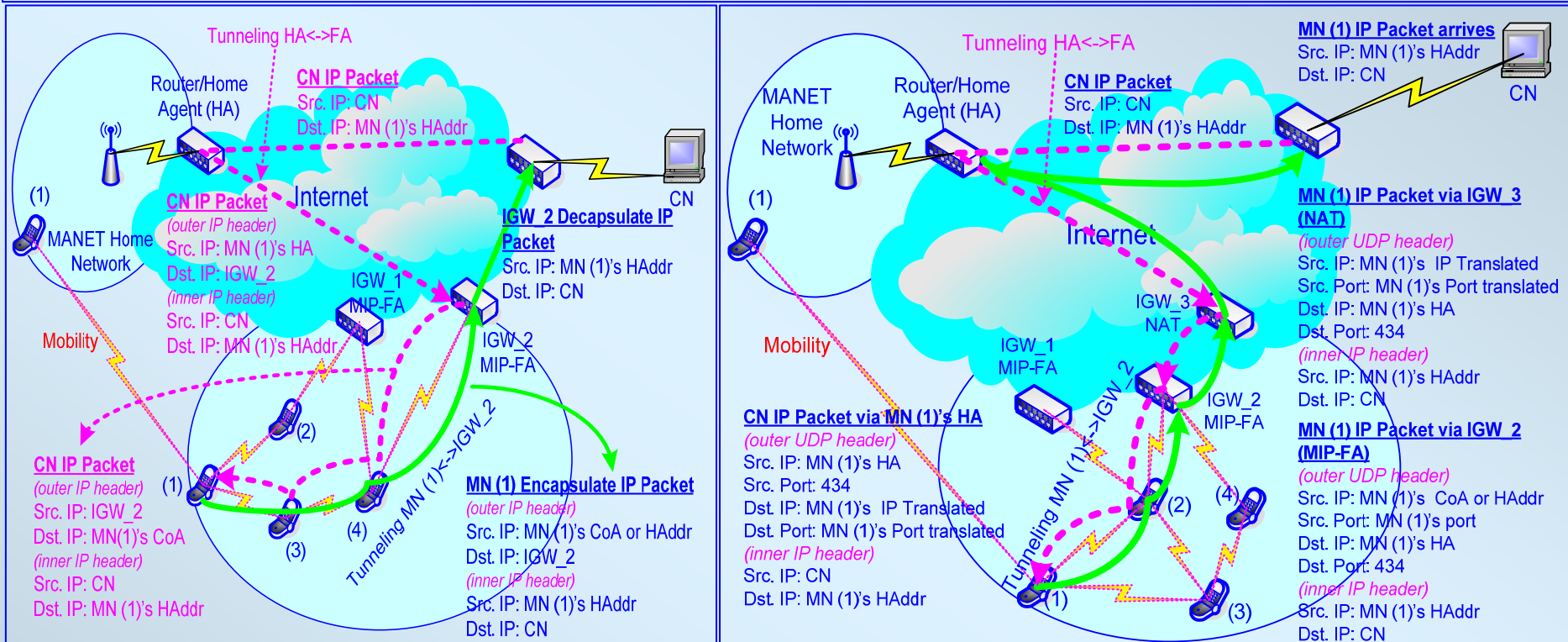


- Inconsistent Context
 - Default Routing (Type I)
 - Default Routing (Type II)
 - Default Routing (Type III)
 - MIPv4-FA Triangle Routing
 - MIPv4-FA Ingress Filtering
- Cascading Effect in MANET Node Location Determination
- MIPv4-FA Traversing NAT

P. E. Engelstad, A. Tonnesen, A. Hafslund, and G. Egeland, "Internet Connectivity for Multi-Homed Proactive Ad Hoc Networks," *IEEE ICC'04*, pp.4050-4056, Jun.20-24 2004.

P. Engelstad, and G. Egeland, "NAT-Based Internet Connectivity for On-Demand Ad Hoc Networks," *WONS'04, LNCS 2928*, pp.342-356, Italy, Jan.19-23, 2004.

Solutions on Internet Gateway Forwarding in MANET



- Inconsistent Context [IP-in-IP Tunneling]
 - Default Routing (Type I)
 - Default Routing (Type II)
 - Default Routing (Type III)
 - MIPv4-FA Triangle Routing
 - MIPv4-FA Ingress Filtering
- Cascading Effect in MANET Node Location Determination [Inserting IGW host route]
- MIPv4-FA Traversing NAT [IP-in MIP UDP-in IP tunneling]

- | <u>CN IP Packet via IGW_3 (NAT)</u> | <u>CN IP Packet via IGW_2 (MIP-FA)</u> | <u>MN (1) IP Packet</u> |
|-------------------------------------|--|--------------------------------|
| <i>(outer UDP header)</i> | <i>(outer IP header)</i> | <i>(outer IP header)</i> |
| Src. IP: MN (1)'s HA | Src. IP: IGW_2 | Src. IP: MN (1)'s CoA or HAddr |
| Src. Port: 434 | Dst. IP: MN (1)'s CoA or HAddr | Dst. IP: IGW_2 |
| Dst. IP: MN (1)'s CoA or HAddr | <i>(inner UDP header)</i> | <i>(inner UDP header)</i> |
| Dst. Port: MN (1)'s port | Src. IP: MN (1)'s HA | Src. IP: MN (1)'s CoA or HAddr |
| <i>(inner IP header)</i> | Src. Port: 434 | Src. Port: MN (1)'s port |
| Src. IP: MN (1)'s HAddr | Dst. IP: MN (1)'s CoA or HAddr | Dst. IP: MN (1)'s HA |
| Dst. IP: CN | Dst. Port: MN (1)'s port | Dst. Port: 434 |
| | <i>(inner IP header)</i> | <i>(inner IP header)</i> |
| | Src. IP: MN (1)'s HAddr | Src. IP: MN (1)'s HAddr |
| | Dst. IP: CN | Dst. IP: CN |

A New Proposed Internet Gateway Selection Metric

$$\text{Min} \{w(i, j)\}_{j \in V_{IGW}} \quad (1)$$

$$w(i, j) = \alpha_1 \cdot D(i, j) + \alpha_2 \cdot LB_{Internet}(j) + \alpha_3 \cdot LB_{MANET}(i, j) \quad (2)$$

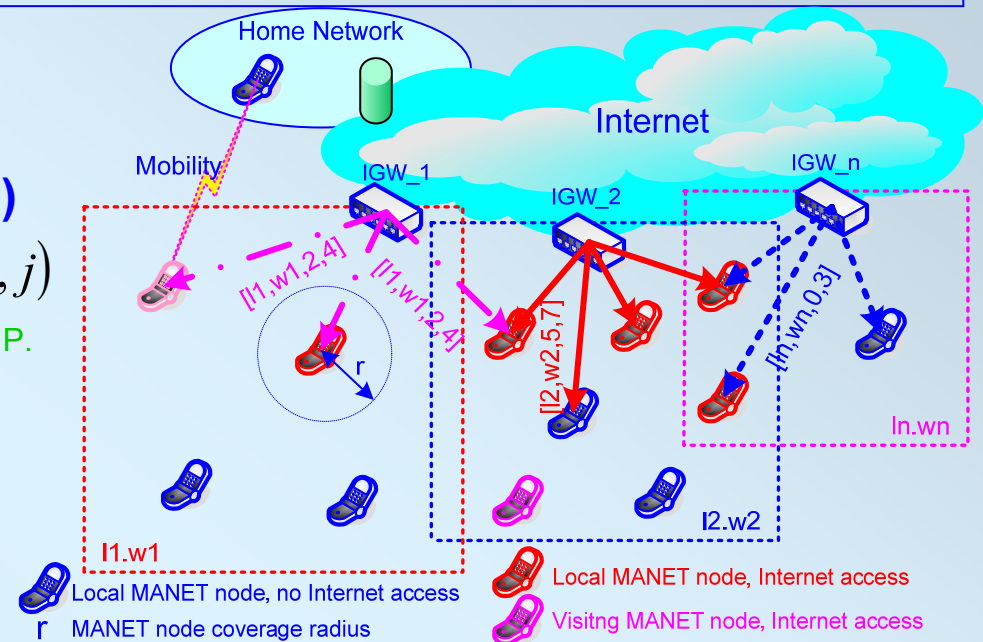
$$\alpha_1 + \alpha_2 + \alpha_3 = 1 \quad (3)$$

$$LB_{Internet}(j) = n_{Reg}(j) \quad (4)$$

Ref. of K in (5): E. M. Royer, P. M. Melliar-Smith, and L. E. Moser, "An Analysis of the Optimal Node Density for Ad Hoc Mobile Networks," *Proceedings of IEEE ICC*, Helsinki, Finland, Jun.2001, pp.857-861.

$$LB_{MANET}(i, j) = \begin{cases} 0 & \text{if } ([AvgDeg(i, j)] \bmod K) = 0 \\ \frac{1}{[AvgDeg(i, j)] \bmod K}, & \text{otherwise} \end{cases} \quad (5)$$

$$AvgDeg(i, j) = \begin{cases} \left(l_j \cdot w_j - \frac{r \cdot (l_j + w_j)}{2} + r^2 \right) \cdot \frac{n_j \cdot \pi \cdot r^2}{(l_j \cdot w_j)^2} & (i : \text{local}) \\ \left(l_j \cdot w_j - \frac{r \cdot (l_j + w_j)}{2} + r^2 \right) \cdot \frac{(n_j + 1) \cdot \pi \cdot r^2}{(l_j \cdot w_j)^2} & (i : \text{visited}) \end{cases} \quad (6)$$



Objectives

- Shortest Euclidean distance (hop-count)
- Load-balancing Internet traffic [in/out]
- Load-balancing Intra-MANET traffic

Ref. of (6): C. Y. Chiu, and C. Gen-Huey, "A stability aware cluster routing protocol for mobile ad hoc networks," *Wireless Communications and Mobile Computing* 2003; 3:503-515.

Contacting Address & References

• Contacting Address

Quan Le Trung & Gabriele Kotsis
Johannes Kepler University, Department of Telecooperation
Altenberger Str. 69, A4040 Linz, AUSTRIA
Tel. +43 (0)732 2468 Ext. 9260 Fax: +43 (0)732 2468 9829
E-mail: {quanle, gk}@tk.uni-linz.ac.at



• References

1. P. E. Engelstad, A. Tonnesen, A. Hafslund, and G. Egeland, "Internet Connectivity for Multi-Homed Proactive Ad Hoc Networks," *IEEE ICC'04*, pp.4050-4056, Jun.20-24 2004.
2. E. M. Royer, P. M. Melliar-Smith, and L. E. Moser, "An Analysis of the Optimal Node Density for Ad Hoc Mobile Networks," *Proceedings of IEEE ICC*, Helsinki, Finland, Jun.2001, pp.857-861.
3. P. Engelstad, and G. Egeland, "NAT-Based Internet Connectivity for On-Demand Ad Hoc Networks," *WONS'04, LNCS 2928*, pp.342-356, Italy, Jan.19-23, 2004.
4. H. Levkowitz, and S. Vaarala, "Mobile IP NAT/NAPT Traversal using UDP Tunneling," *Internet Draft draft-ietf-mobileip-nat-traversal-07.txt*, <http://tools.ietf.org/id/draft-ietf-mobileip-nat-traversal-07.txt>.
5. E. Ancillotti, R. Bruno, M. Conti, E. Gregori, and A. Pinzzotto, "A Layer-2 Framework for Interconnecting Ad Hoc Networks to Fixed Internet: Test-bed Implementation and Experimental Evaluation," *The Computer Journal*, ISSN 1460-2067, pp.2-22, May.11 2007.
6. F. M. Abduljalil, and S. K. Bodhe, "A Survey of Integrating IP Mobility Protocols and Mobile Ad Hoc Networks," *IEEE Communications Surveys and Tutorials*, pp.14-30, Vol.9, No.1, 1st Quarter 2007.

Thank You!