
# Location Privacy in MobileIP$v6$

"Tracking the binding updates"

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# ▷ *Agenda*

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▷ ***About secure communications***

▷ ***MobileIP Route optimization***

▷ ***Stateless Address Autoconfiguration vs Privacy***

▷ ***The problem(s)***

▷ ***The goal***

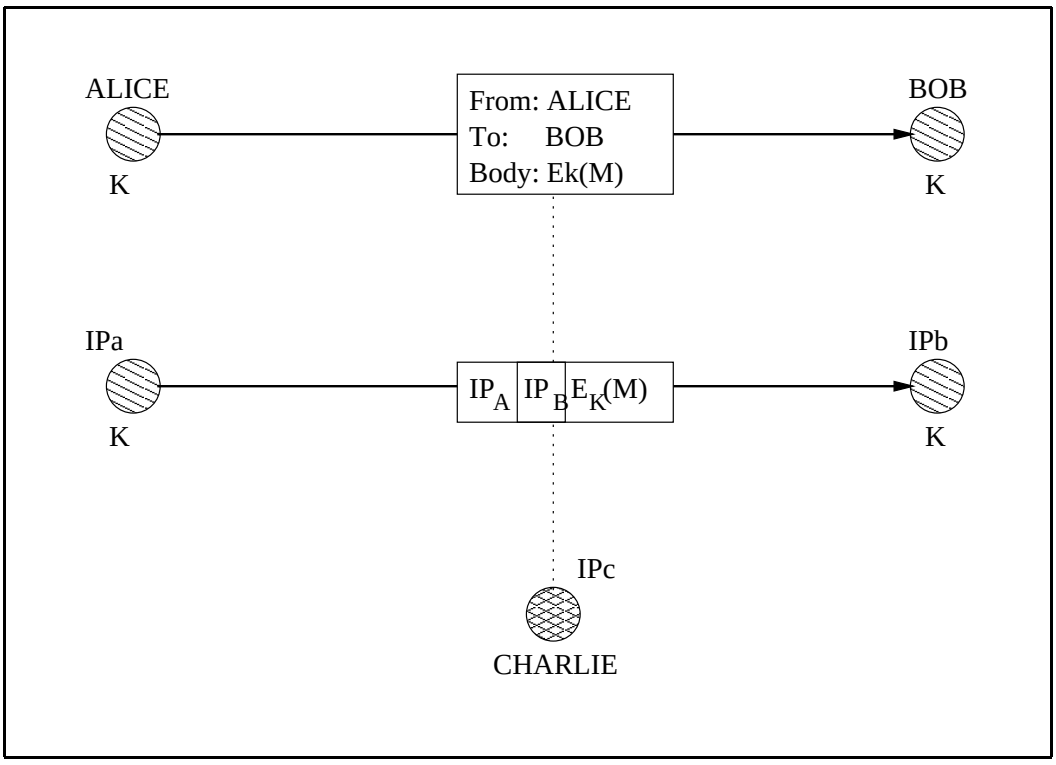
▷ ***Some solutions: RFC3041, TMI, HMIP$v6$, Cloaking, Freedom AIP***

▷ ***Conclusions***

# ▷ *Secure communications*

Alice sends a $Message$ to Bob

- **Integrity**: No alteration of $Message$
- **Authentication**: Alice $is$ Alice, Bob $is$ Bob.
- **Confidentiality:** Charlie can not read $Message$



# ▷ *Secure communications*

$Alice \overset{E_k(M)}{\Rightarrow} Bob$

| | |
|---|---|
| ***00 00 0c 07 ac 14*** **00 60 1d f1 64 d4** 08 00 45 00 | $MAC_R - MAC_B$ |
| 00 54 4a 26 00 00 40 01 f5 92 ***82 ed 14 e3*** **82 ed** | $IP_A$ |
| **20 33** 08 00 62 e1 1c 05 02 00 57 2d 1a 3b 19 ae | $IP_B$ |
| 01 00 08 09 0a 0b 0c 0d 0e 0f 10 11 12 13 14 15 | $E_k(M)$ |
| 16 17 18 19 1a 1b 1c 1d 1e 1f 20 21 22 23 24 25 | $E_k(M)$ |
| 26 27 28 29 2a 2b 2c 2d 2e 2f 30 31 32 33 34 35 | $E_k(M)$ |

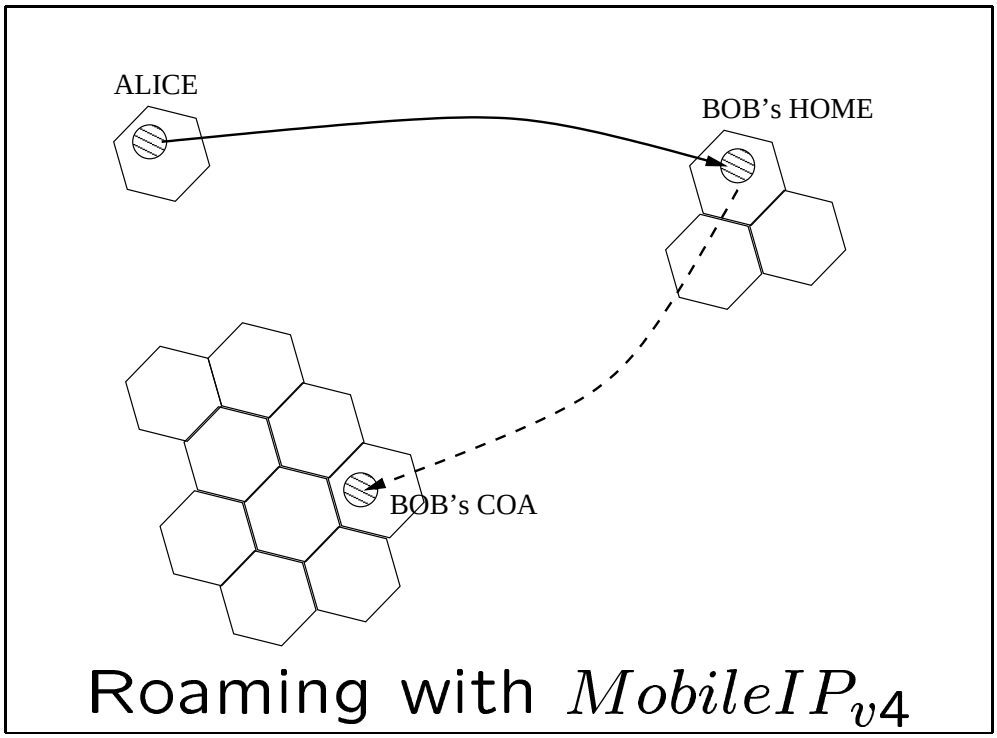
$Charlie$ doesn't know about $M$ but knows:

- That $Alice$ is sending $E_k(M)$ to $Bob$

- $MAC_{\{A,B\}}$ if present in $Link_{\{A,B\}}$

# ▷ MobileIPv4

$Alice$ sends a $Message$ to $Bob$
$Bob$ is away from $Home_{Bob}$
$Home_{Bob}$ delivers the $Message$ to $Bob's\ care-of-address$



Roaming with $MobileIP_{v4}$

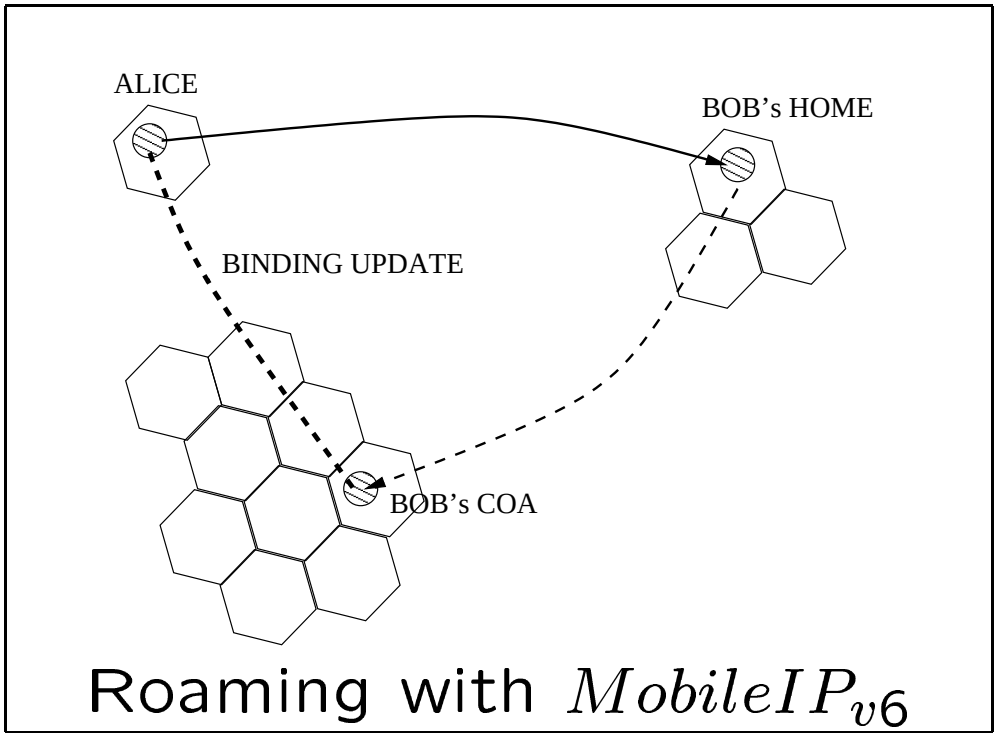
- Bidirectional tunneling conceals $COA_{Bob}$ from $Alice$ but not from $Home_{Bob}$ or $Charlie$.

- $IP_{v4}$ *Route optimization* is not possible with a random correspondent node.

# ▷ *MobileIPv6*

≈$MobileIP_{v4}$ + Routing Optimization

| |
|---|
| $Bob$ can send a $Binding\ Update$ to $Alice$ |
| $Alice$ can send a $Binding\ Request$ to $Bob$ |




Roaming with $MobileIP_{v6}$

# ▷ MobileIPv4

$Alice \overset{E_k(M)}{\Rightarrow} Bob_{HA} \overset{E_k(M)}{\Rightarrow} Bob_{COA} \overset{E_k(M)}{\Rightarrow} Bob$

At home: CN⇒MN

Roaming: CN⇒(HA⇒COA)⇒MN

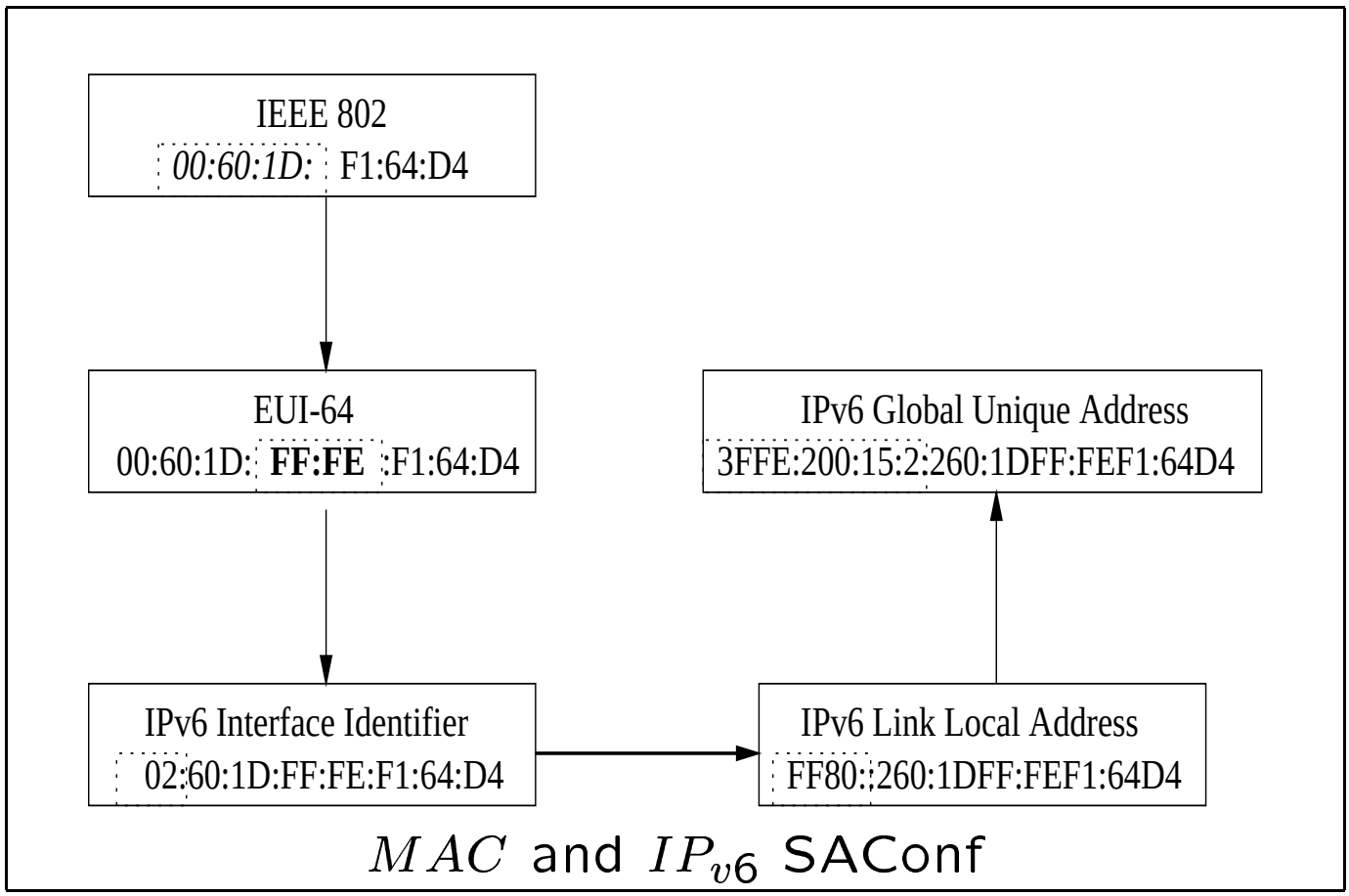
| | |
|---|---|
| ***00 60 1d f1 64 d4*** **00 02 4b de ea d8** 08 00 45 00 | $MAC_B$ - $MAC_r$ |
| 00 68 b7 ee 40 00 3e 04 94 e2 ***82 ed d5 03*** **82 ed** | $IP_{HA} \Rightarrow IP_{COA}$ |
| **14 e3** 45 c0 00 54 7d 70 00 00 f9 01 47 79 ***82 ed*** | |
| ***20 34*** **82 ed d5 f0** 00 00 06 25 4b 07 22 00 e2 39 | $IP_{CN} \Rightarrow IP_{MN}$ |
| 1a 3b a2 5b 03 00 08 09 0a 0b 0c 0d 0e 0f 10 11 | $E_k(M)$ |
| 16 17 18 19 1a 1b 1c 1d 1e 1f 20 21 22 23 24 25 | $E_k(M)$ |
| 12 13 14 15 16 17 18 19 1a 1b 1c 1d 1e 1f 20 21 | $E_k(M)$ |
| 22 23 24 25 26 27 28 29 2a 2b 2c 2d 2e 2f 30 31 | $E_k(M)$ |

$Charlie$ doesn't know about $M$ but knows that:

- $Alice$ is sending $E_k(M)$ to $Bob's\ home\ network$
- $Bob$ is not at $home$
- $Bob$ is roaming using his $care-of-address$

In $MobileIP_{v6}$:

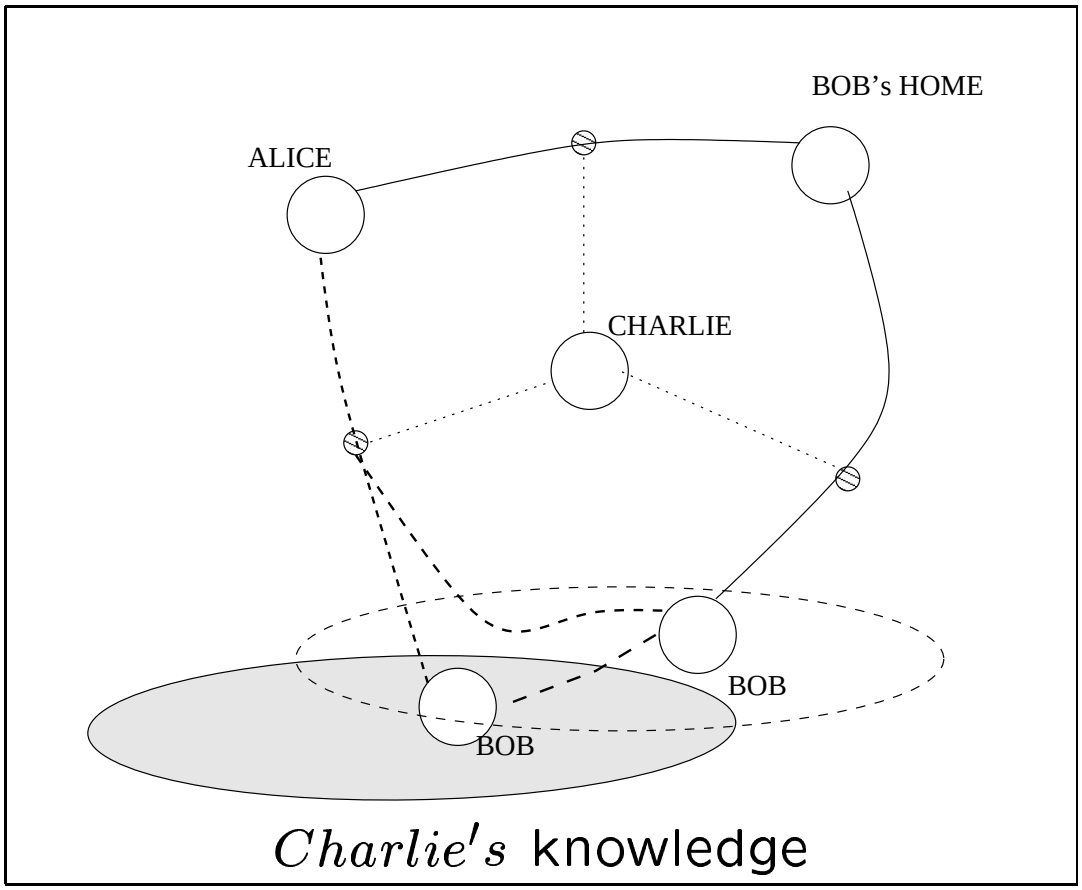
- $Alice \approx Charlie$




The IP$v$6 address generated via Stateless Autoconfiguration contains:

The **same interface identifier** regardless of the **location** the mobile node is attached to the Inet.

# ▷ *The problem*




- $Charlie$ can obtain consecutive $COA_{Bob}(t)$

- $Bob's\ movements$ can be easily tracked

- $Bob's\ IP$ activities are linked with his location

# ▷ The “goal”

*Allow a mobile node to **seamlessly “roam”** among IP subnetworks and media types whilst being **untraceable***

**- Untraceable:**

The capability of the mobile node to conceal the relation between its personal identifiable information and geographical location from third parties

| |
|---|
| $Home_{Bob}$ doesn't know $Foreign_{Bob}$ |
| $Foreign_{Bob}$ doesn't know $Home_{Bob}$ |
| $Charlie$ doesn't know $Home_{Bob}$ and $Foreign_{Bob}$ |
| $Charlie$ doesn't know $Bob$ is talking with $Alice$ |

# ▷ $IP_{v6}$ Privacy Extensions

## RFC & Internet Drafts

- **RFC3041**
T. Narten (IBM)- R. Draves (Microsoft)
*"Privacy extensions for $IPv6$ Stateless Address Autoconfiguration".*

- **Internet Draft - MobileIP privacy**
C. Castelluccia (INRIA) - F. Dupong (ENST).
*"A Simple Privacy Extension for Mobile IPv6".*

- **Internet Draft - Hierarchical MobileIP$v6$**
H. Soliman (Ericsson), C. Castelluccia (INRIA)
K. El-Malki (Ericsson) - L. Bellier (INRIA).
*"Location privacy with HMIP$v6$ basic mode".*

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## Papers

- **Cloaking: Location Hiding in IP$v6$**
J. Wells and C. Castelluccia (INRIA).

- **Anonymous Internet Proxies and Location Hiding**
A. Escudero , M. Hedenfalk, P. Heselius. (KTH)
*"Location Privacy in Mobile Internet - An extension to Freedom Network"*. INET2001.

**RFC3041**

"Privacy ext. for $IPv6$ Stateless Address Autoconfiguration"

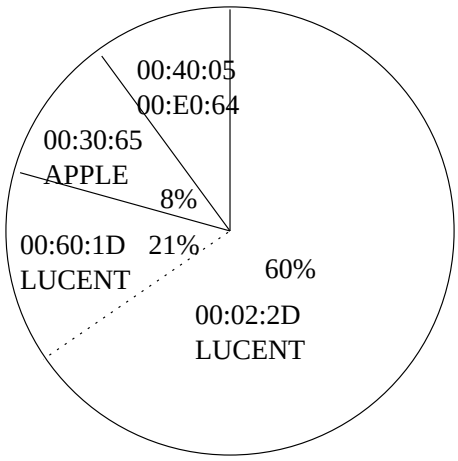
## *Main idea*

- Interface Identifier is generated randomly (history scheme)

## *Better solution*

- Unobservable pseudo random interface identifier.

Lucent 81% - Apple 8%




$IEEE$ 802.11$B$ MAC distribution

580 wireless users @ Hackers at Large 2001

12:34:DE:AD:DE:AD $\Rightarrow$ Private IEEE 80211

***The Home address of a MN is present in***

- Home address destination option.

- Corresponding node routing header.

***MobileIP Privacy Extension main idea is***

When MN initiates the communication then:

- The MN sends the TMI instead of Home Address in the destination option.

- The CN sends the TMI in the routing header.

***Requirements***

- A dedicated TLA identifier (16 bits) should used (112 bits for TMI).

***Drawbacks***

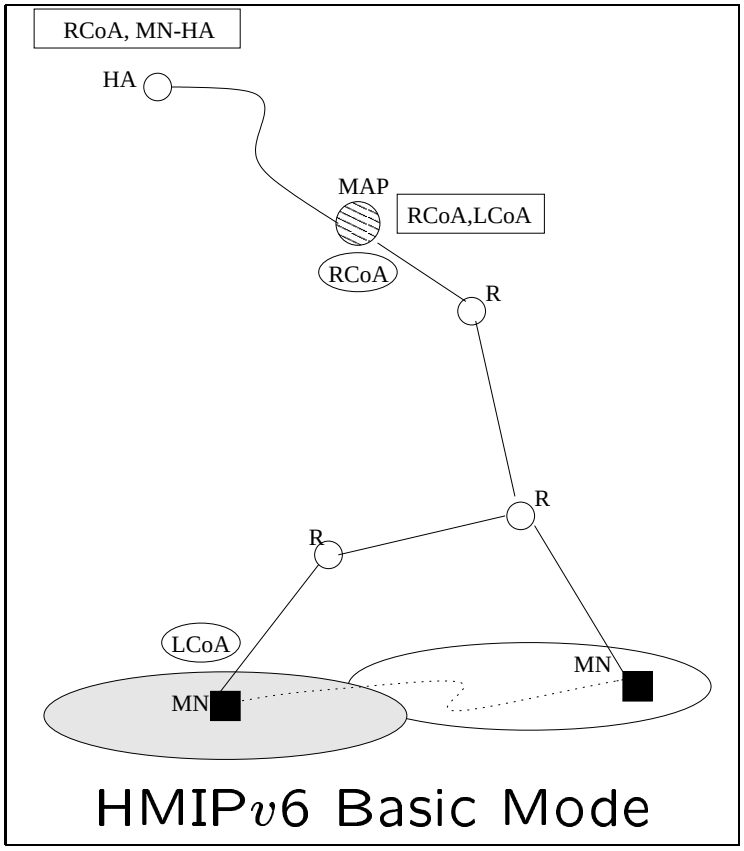
- The first 16 bits are fixed

- A “privacy enable” TMI is very easy to recognize.

- Private TLA is unroutable.

**Internet Draft-Soliman**

Privacy extension in HMIP$v$6 basic mode




HMIP$v$6 Basic Mode

***The HMIP$v$6 Basic mode:***

- Use MAP (Mobility Anchor Point) as HA

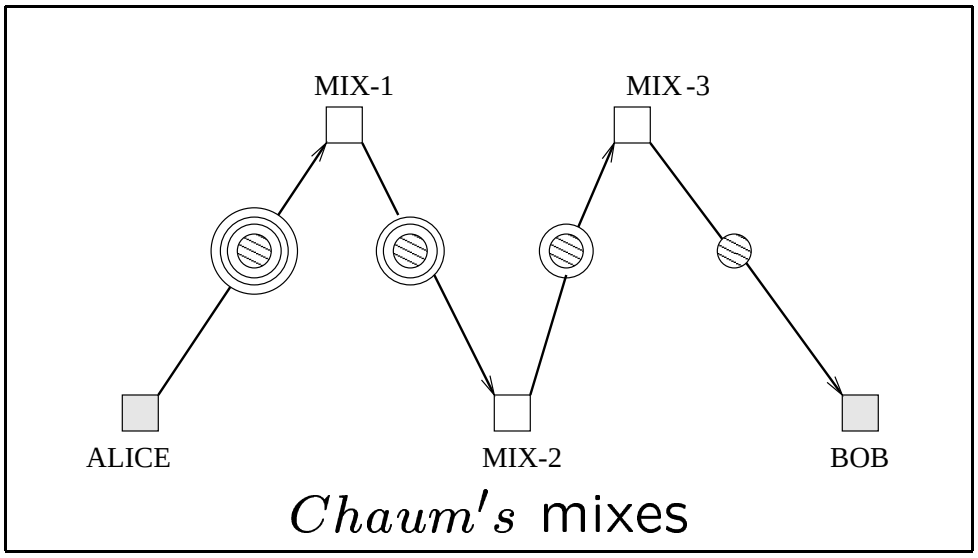
- The MN obtains a RCoA and registers LCoA - RCoA in the MAP.

- The MN registers the RCoA with its HA.

- The MAP will receive packets addressed to the MN's RCoA (from the HA or CNs).

- The MAP tunnels from the MAP to the MN's LCoA.

# ▷ *The core technology*



$Chaum's$ mixes

- **Mixes**
(D. Chaum -1981)

- **Onion Routing**
(M. Reed, P.Syverson and D.Goldschlag - 1996)

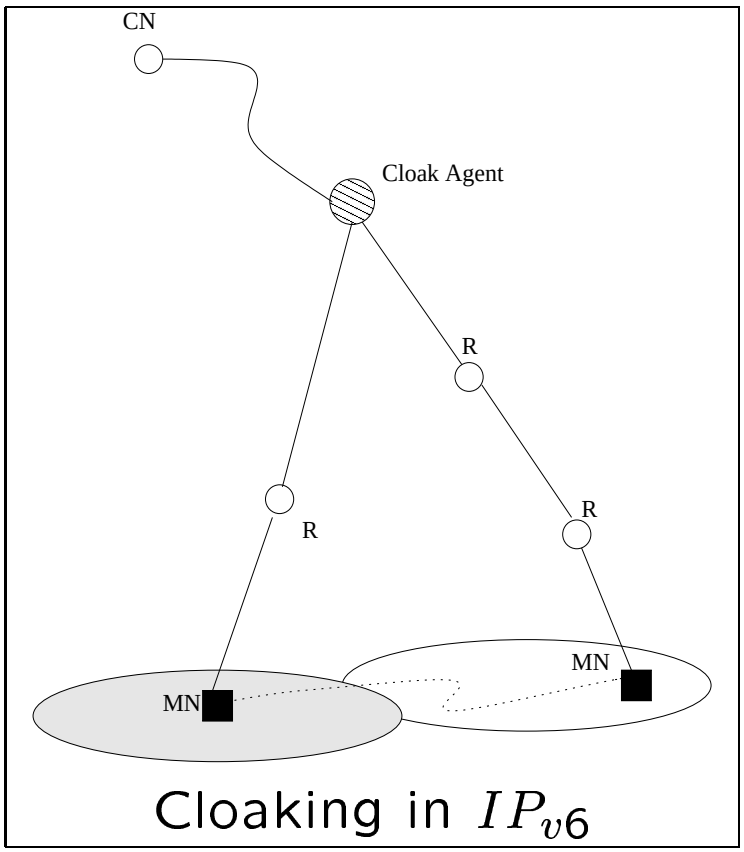
- **Non Disclosure Method (NDM)**
(A.Fasbender, D. Kesdogan and O. Kubitz - 1996)

- **Pseudonymous IP Network (PIP)**
(I. Golberg - 2000)

- **Freedom System**
(Zero Knowledge Systems Inc.)

## Cloaking IPv6

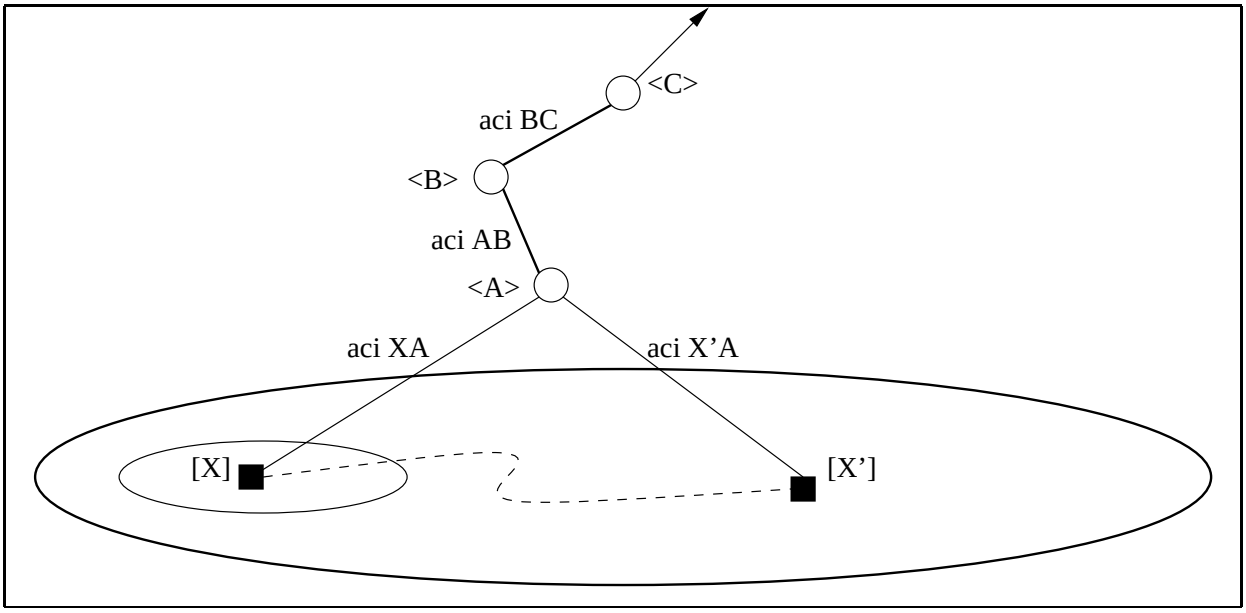
Location hiding in IP$v6$




- Similar to HMIP$v6$ Basic Mode

but:

- Uses bi-directional tunnel.
- Cloacking agents (≈MAPs) are not announced.




**Freedom PIP Network:**

- Provides privacy protection

- The Anonymous Internet Proxies $AIP_i$ are the core privacy daemons

- The Freedom Client creates a "virtual circuit" inside of the freedom network

- Multilayer nested encryption (Telescope encryption)

- Route to next hop by use on Anonymous Circuit Identifier $ACI$

- The $AIP_{exit}$ or freedom wormwhole acts as a $NAT$

**The Freedom Mobility extensions allow:**

- Rebuilding parts of the virtual link without notifying to the exit point.

# ▷ *Conclusions*

* Encryption does not solve all security/privacy problems.

* Users interested in privacy protection are highly observable.

* Route optimization vs Privacy.

* MobileIP and HMIP$v$6 features can be used.

* "Mixing" technologies will be again applied.

* Maybe in IP$v$7 ?