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Address Auto- configuration for Wireless Mesh Networks

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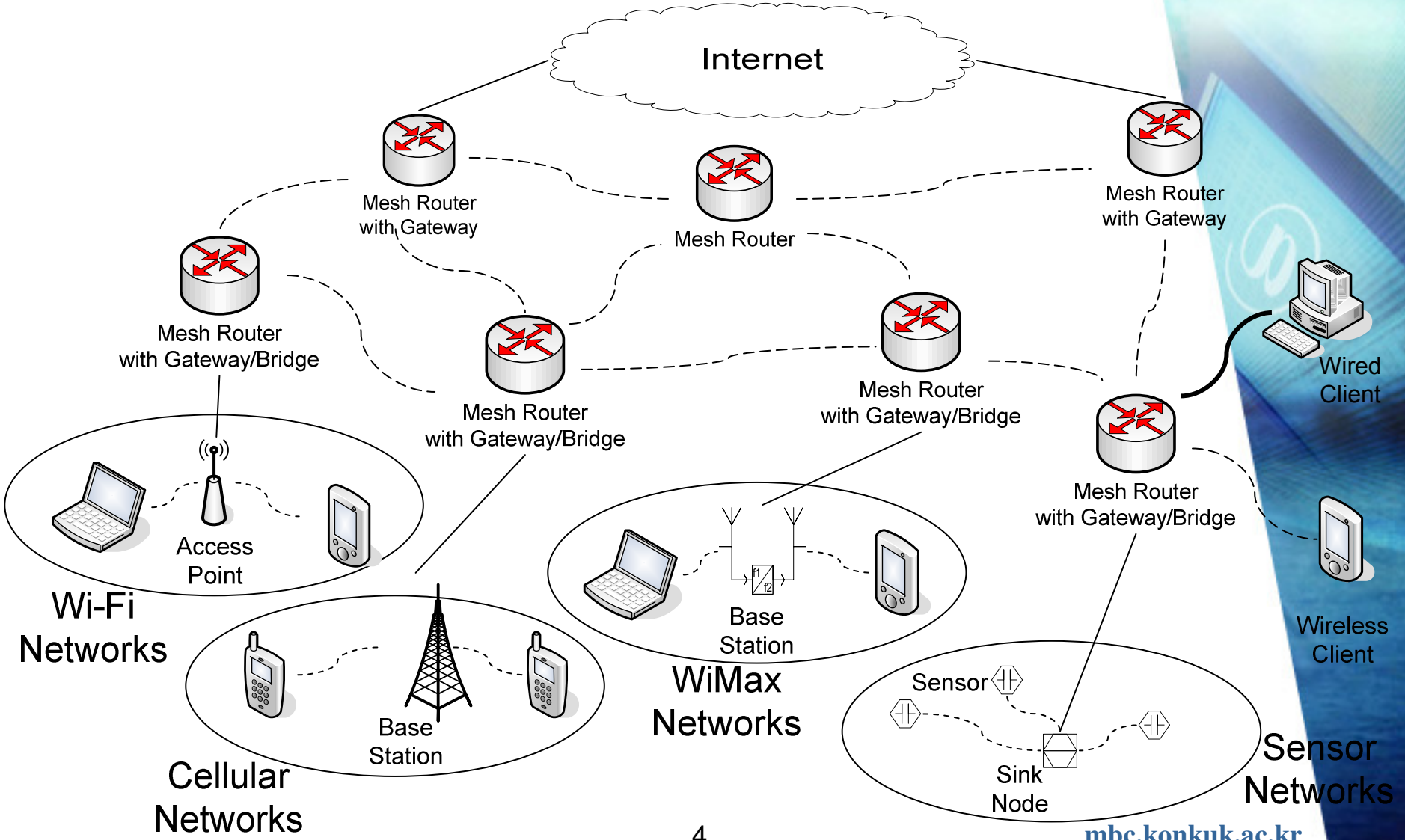
Wireless Mesh Networks

Mesh Network Structure

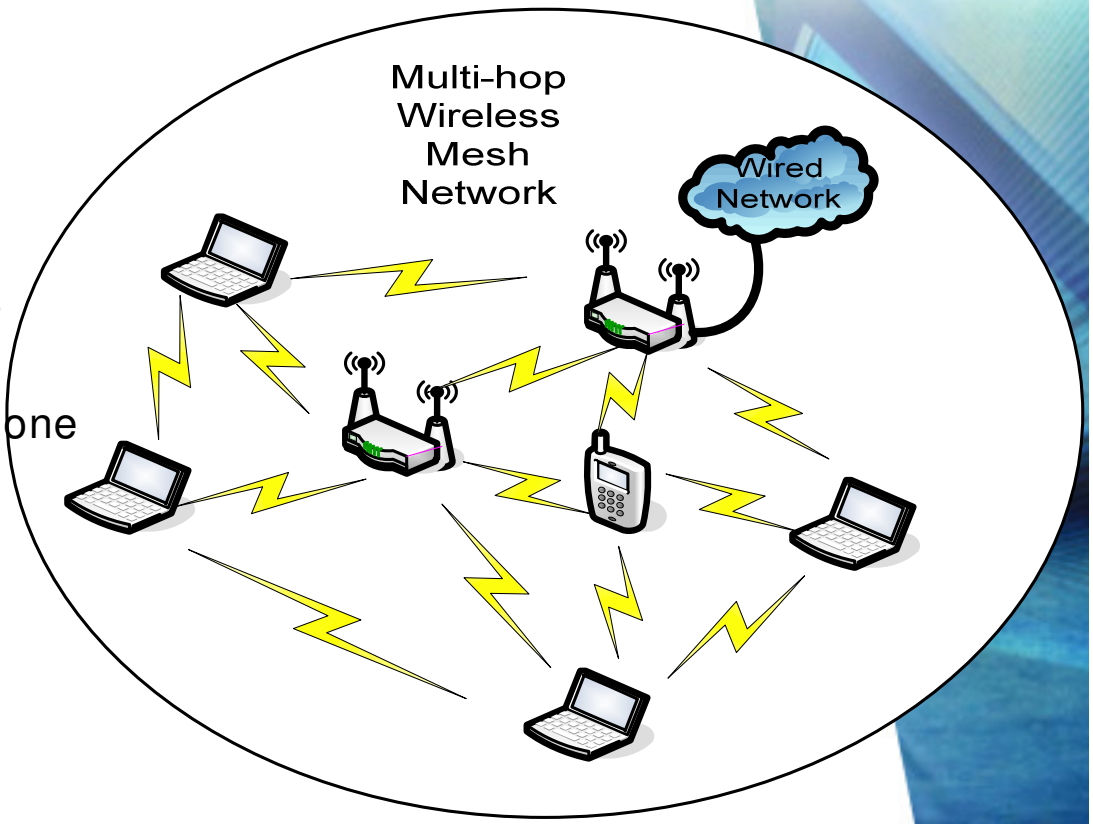


Wireless Mesh Network

- ***Mesh networks can be seen as one type of ad- hoc network***

- ***Network Architecture***
  - Infrastructure/Backbone WMNs
  - Client WMNs: MANET
  - Hybrid WMNs: MANET + Backbone WMN
  - Multihop wireless network

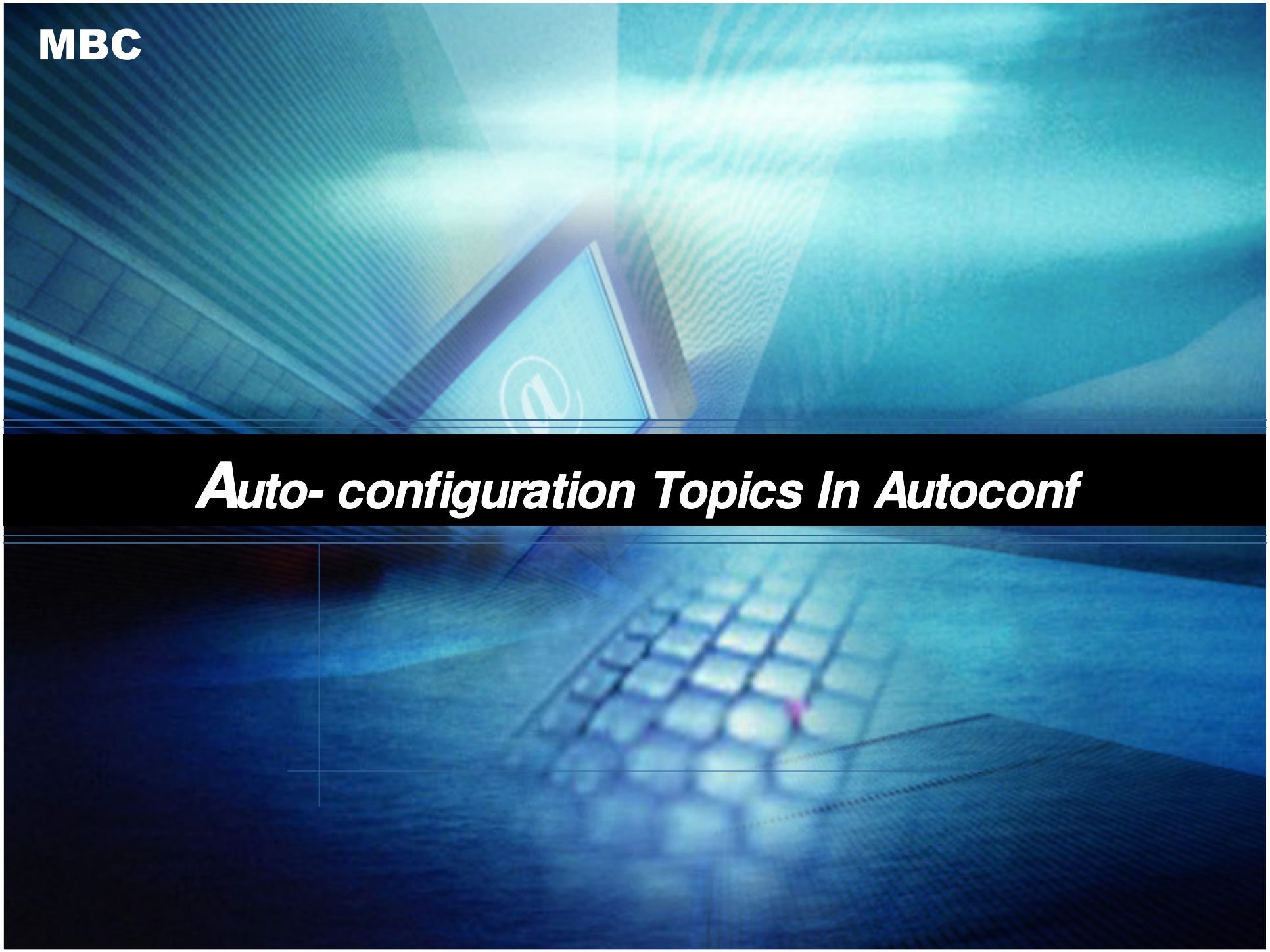
* (WMN = Wireless Mesh Network)



Wireless Mesh Network

Necessity of Auto- configuration

- ***Mesh network nodes need Global Address in order to connect Internet***
  - ***So, Global Address auto- configuration is necessary in Mobile mesh networks***
  - Mesh network auto- configuration is similar to Ad- hoc network auto- configuration using Internet gateway
- Problems of IPv6 Auto- configuration in mesh/ad- hoc networks
  - Multi- hop Routing Problem
    - Without unique global IPv6 address, packets cannot be transferred to the destination through multi- hop topology.
  - Host Unreachable Problem
    - Broadcasting Packets for DAD may not be reachable to some nodes in mesh/ad- hoc networks.
  - Timeouts Problem
    - In mesh/ad- hoc networks, message delay cannot be bounded.
    - Thus the use of timeouts cannot reliably detect the absence of a message.
- IETF Autoconf WG
  - Autoconf WG is to standardize mechanisms to be used by ad hoc nodes for configuring unique local and/or globally routable IPv6 addresses.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Auto- configuration Topics In Autoconf

Background

- ***Ad hoc node may need to auto- configure either or both of:***
  - Global scope address, if a gateway is available
  - MANET- local scope address, for standalone networks
- ***Current status:***
  - No standard mechanism and definition related to auto-configuration of ad hoc node
- ***MANET list has carried discussions of auto- configuration ideas and requirements almost since [manet] was chartered.***
- ***Has never been a charter item***
- ***There have been several auto- configuration drafts***
  - None of them have been accepted as working group drafts
- ***Many outside projects (e.g., military) have shown the need***

Main TOPIC in Autoconf WG

- ***OSI Observations on "Link"***
- ***MANET/Autoconf Using DHCP***
- ***MANET Subnet Model- IPv6***

TOPIC – Observations on "Link"

- ***OSI Reference Model***
  - OSI reference model 3- sublayer decomposition for L3:
    - Internet sublayer (Layer- 3c) - IP layer
    - link enhancement sublayer (Layer- 3b) - intra- MANET routing; tunneling to harmonize heterogeneous links (if needed)
    - link access sublayer (Layer- 3a) - IP- to- MAC address mapping layer

      Link Characteristics
- ***Link Characteristics***
  - For MANET Routers on semi- broadcast links (i.e., transmission- range- limited links), "link" can mean:
    - transmission- range- limited neighborhood
    - entire MANET (Layer- 3a or Layer- 3b with tunneling)

TOPIC - MANET/Autoconf Using DHCP (1)

- ***First- Order Considerations***
  - MRs configure MLA(MANET Local Address)s and engage in the MANET routing protocol
  - MGs link MANET to provider network or global internet, and configure a DHCP relay/server
  - Two choices:
    - MR configures DHCP client- only and tunnel client's broadcast/multicast requests across MANET to MGs
    - MR configures both DHCP client and DHCP relay, and forwards its own requests to MGs

TOPIC - MANET/Autoconf Using DHCP (2)

- ***Client- only Tunneling Method***
  - requires either application- specific relays or treat entire MANET as a "link" using intra- site tunneling, e.g., 6over4, ISATAP, etc.
  - Multicast- in- multicast tunneling requires SMF;
    Multicast- in- unicast tunneling requires MG
    address discovery (e.g., via tunneled RAs)
  - DHCPv4 requires new "MLA Option" so MGs can relay DHCP Replies to correct MR
  - DHCPv6 can put MLAs in "peer- address"

TOPIC - MANET/Autoconf Using DHCP (3)

- ***Client- relay Forwarding Method***
  - ***DHCP client/relay approach:***
    - MR configures both DHCP client and relay
    - client and relay talk over loopback interface
    - no need for tunneling
    - works for DHCPv6; haven't found a way to make it work for DHCPv4 yet

TOPIC - MANET Subnet Model- IPv6 (1)

- ***"Classical IP Subnet" Model***
  - MANET interfaces configure link- local (LL) addresses and shared prefix for both address configuration; on- link determination (i.e., prefix length shorter than 128):
    - all MANET interfaces that assign the prefix and configure addresses from the prefix must be attached to the same link and run DAD on the link
    - useful only for MANETs that comprise a single link (either L3a or tunneled L3b)
    - ***multilink subnet*** for L3b MANETs w/o link- enhancement

TOPIC - MANET Subnet Model- IPv6 (2)

- ***"No- Subnet" Model (aka "Multi- subnet MANET" Model)***
  - MANET interfaces configure LL and MLAs only; global prefixes procured for non- MANET links:
    - Probabilistically- unique MLAs used for intra- site communications
    - Global prefixes delegated for non- MANET links using, e.g., "MANET Autoconf using DHCP" – no DAD needed over MANET interface since globals applied to non- MANET links
    - With SEND LLs, proxy/relay- DAD needed in case colliding nodes move onto the same link
    - When LL's administratively configured for uniqueness, proxy/relay- DAD not needed

TOPIC - MANET Subnet Model- IPv6 (3)

- ***"/64 Subnet- Per- Interface" Model***
  - MANET interfaces configure unique prefix (/64 assumed):
    - Global prefixes delegated for MANET links using TBD autoconf mechanism.
    - Autoconf mechanism can't be DHCP prefix delegation since prefix is assigned to MANET interface
    - proxy/relay DAD not needed for globals

- ***"Singleton Subnet- Per- Interface" Model***
  - MANET interfaces configure shared prefix for address configuration but not on- link determination (i.e., prefix length = 128)
    - proxy/relay DAD needed for both LLs, globals

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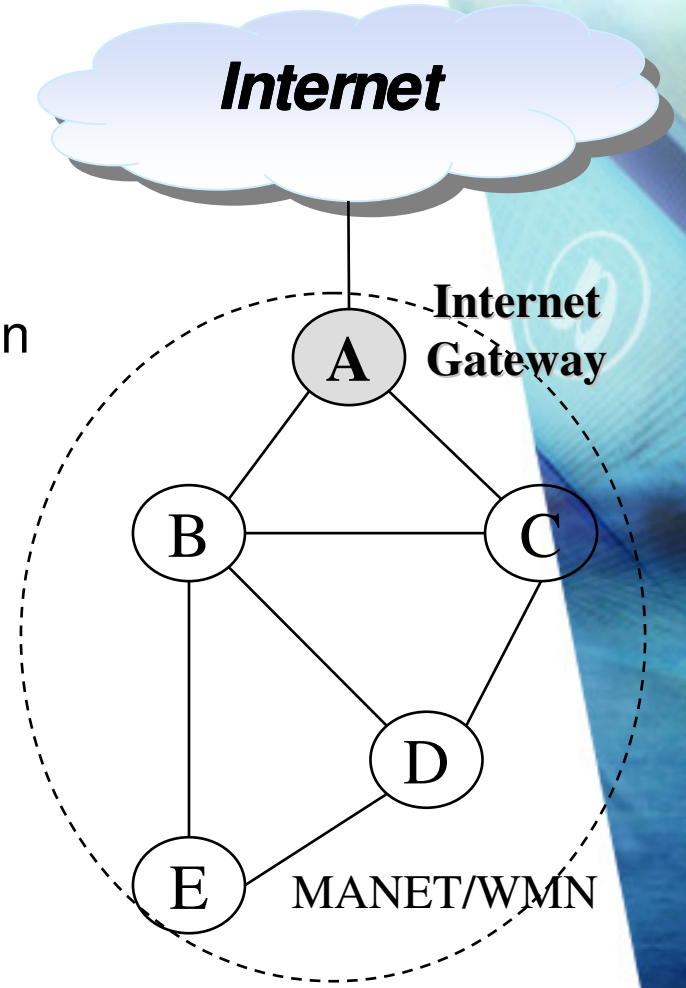
Proposed Ideas

auto- configuration

- ***Objectives***
  - Support Global IPv6 address auto- configuration for Wireless Multi- hop Access Networks (WMN or Mobile Ad- hoc Network)
  - Wireless Multi- hop Access Networks are connected to Internet
  - Independent of Ad- hoc/Mesh networks routing protocols
  - Stateless
  - Stateful
  - The DAD for link- local address is done by the same mechanism as IPv6 link- local address auto- configuration

Internet Gateway

- Internet Gateway
  - Provides Internet connectivity to other nodes in MANET/WMN
  - Participates in auto- configuration process



Stateless Address Auto- configuration

- ***How to get global prefix***
  - Using Advertisement Message from neighbor nodes
  - This message includes Router Advertisement message of Internet Gateway.
- ***How to send packets through multi- hop without global address***
  - a new node entering the network chooses a reachable neighbor node that can perform DAD for itself.
    - Tunneling
- ***Internet Gateway***
  - has a table that includes address information of all nodes in a network.
  - Internet Gateway manages and uses this table for performing DAD.

Stateless Address Auto- configuration

- ***DAD for Global Address***
  - After configure link- local address, a new node selects a proper neighbor node(selected node) and sends a Neighbor Solicitation for global DAD to the selected node.
  - Selected node performs T- DAD(Tunneled DAD) with Internet Gateway on behalf of the new node.
  - Selected node sends encapsulated NS of new node to the Gateway.
  - The Gateway checks whether the target address in the Neighbor Solicitation is identical with any IP address in its address table.
  - If there is no same address in the table, Internet Gateway adds an entry with the requested address information in the table and reply success message to the selected node.
  - If there is a same address, Internet Gateway reply failure message to the selected node.
  - Then the selected node forwards the result to the new node.

Stateful Address Auto- configuration

- ***Stateful Approach***
  - Internet Gateway has available address pool and allocates addresses to other nodes.
  - DAD procedure is not necessary.

- ***Use Proxy Nodes***
  - In order to allocate address more fast.
  - Proxy node shares address pool with other Proxy nodes and Internet Gateway.

- ***A node who want to configure a new global address can receive address from Internet Gateway or Proxy.***
  - First, the node request a global address to Internet Gateway or Proxy.
  - And then, Internet Gateway or Proxy responses to the node with an unique global address.

Basic Operation (2)

- ***In order to allocate the addresses in ad- hoc network, we use new IPv6 addressing format.***
  - Interface ID field in normal IPv6 address is divided into two parts, Proxy IP and Host ID
  - Proxy ID
    - Allocated by Internet Gateway to proxy nodes
  - Host ID
    - Allocated by proxy nodes to new nodes.

Global Network Prefix	Proxy ID	Host ID (Free Space)

Basic Operation (3)

- ***Address allocation by Internet Gateway***
  - Gateway allocates Ad- hoc prefix
  - Set Host ID as 0
  - The node who received address from GW becomes a proxy node.

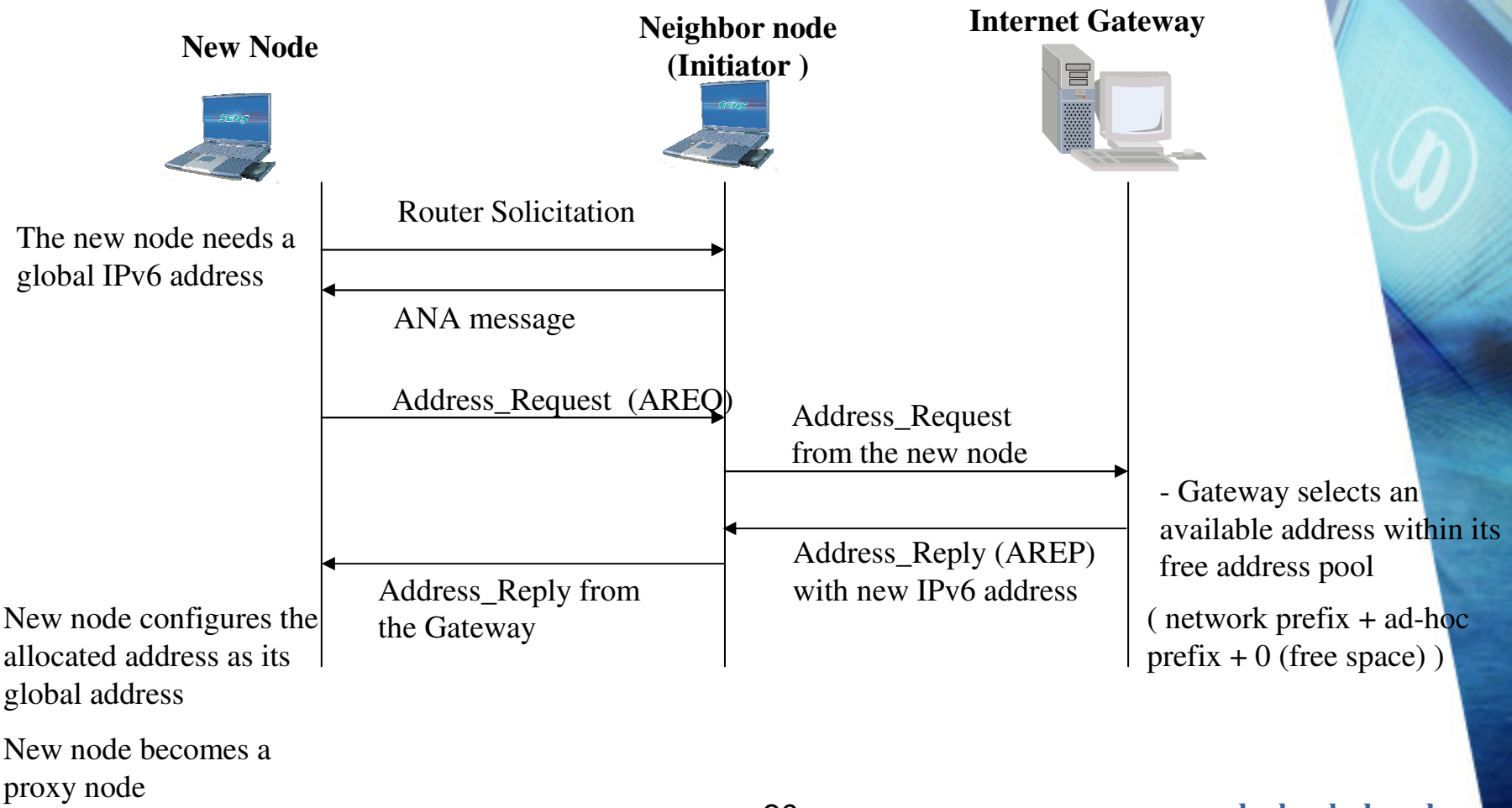
- ***Address allocation by Proxy Nodes***
  - Proxy node can allocate addresses on behalf of the Internet Gateway
  - Host ID part is a free address pool for proxy
  - Proxy can freely allocate addresses within Host ID part to other nodes.

Address Allocation Example

- ***Example***
  - Prefix length : 64 bits
  - Ad- hoc Prefix length : 48 bits
  - Host ID length : 16 bits
  - When the Internet Gateway allocates the new address to node A
    - selects an unused value as Ad- hoc Prefix and sets the value of Host ID as 0
    - Ex) 3ffe:2e01:2b:1111:2222:2222:2222:0000
      - 3ffe:2e01:2b:1111 - > Network prefix
      - 2222:2222:2222 - > ad- hoc prefix
  - Now, node A becomes a proxy
    - it can allocate an address to another node by using free space of Host ID
    - ***from*** 3ffe:2e01:2b:1111:2222:2222:2222:***0001***
    - ***to*** 3ffe:2e01:2b:1111:2222:2222:2222:***FFFF***
  - As usual, proxy uses 3ffe:2e01:2b:1111:2222:2222:2222:0001 as own.
  - The address, which all bits of Host ID are set to 0, must be used as a proxy- scope multicast address. (for address management)

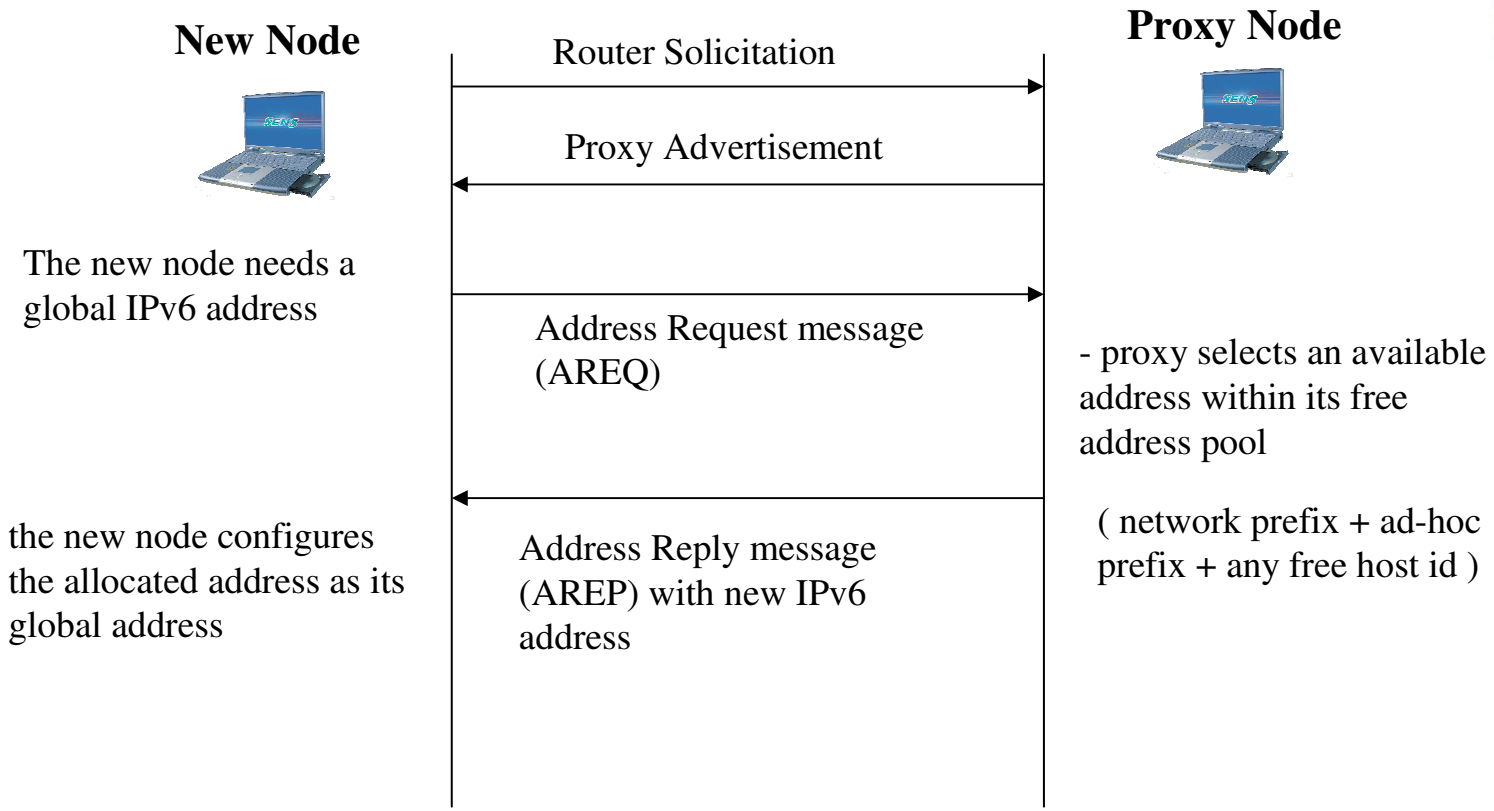
Address Auto- configuration in MANET (4)

- **Case 1 : There are no proxy nodes**



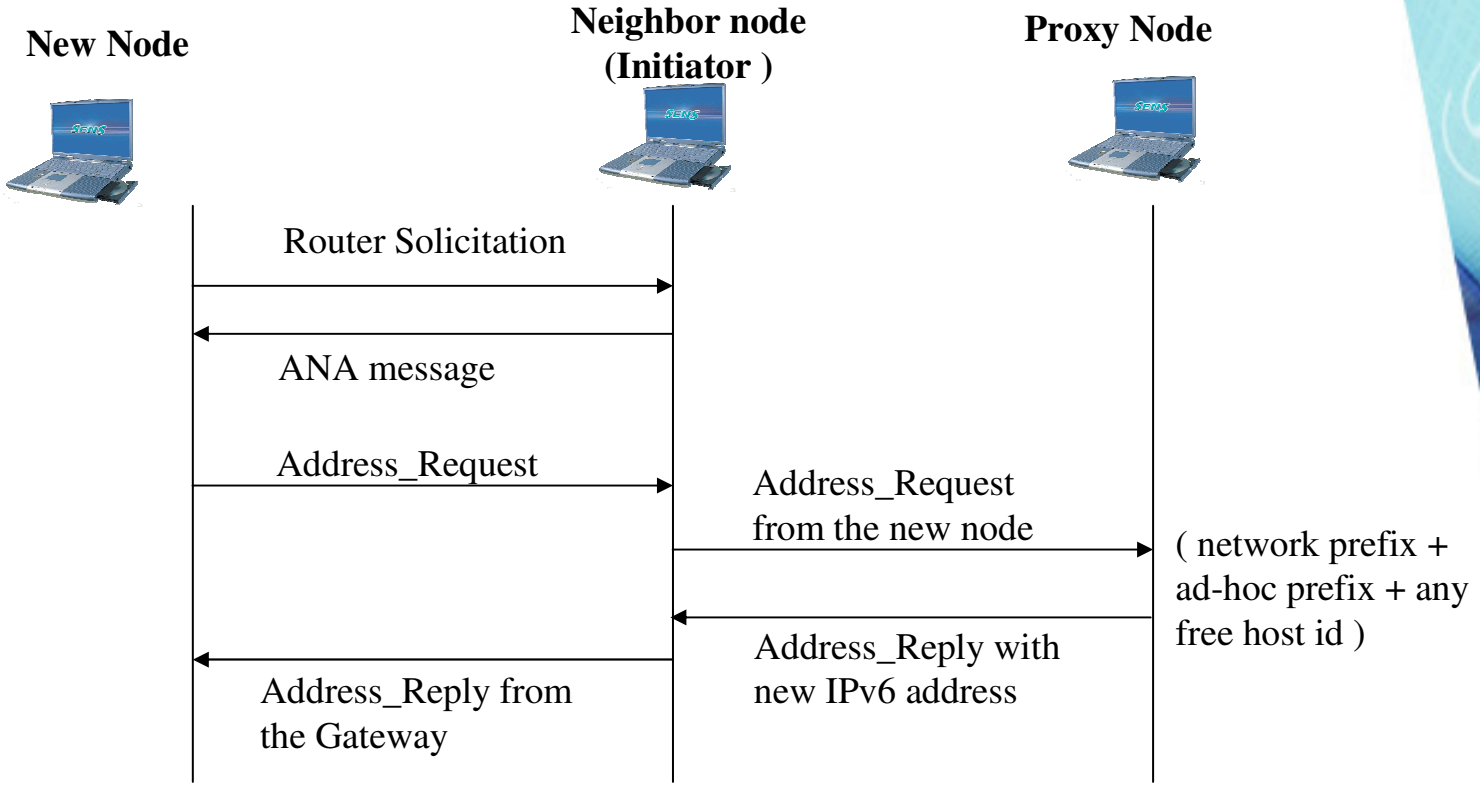
Address Auto- configuration in MANET (5)

- **Case 2 : There are some proxy nodes within one- hop distance from the new node**



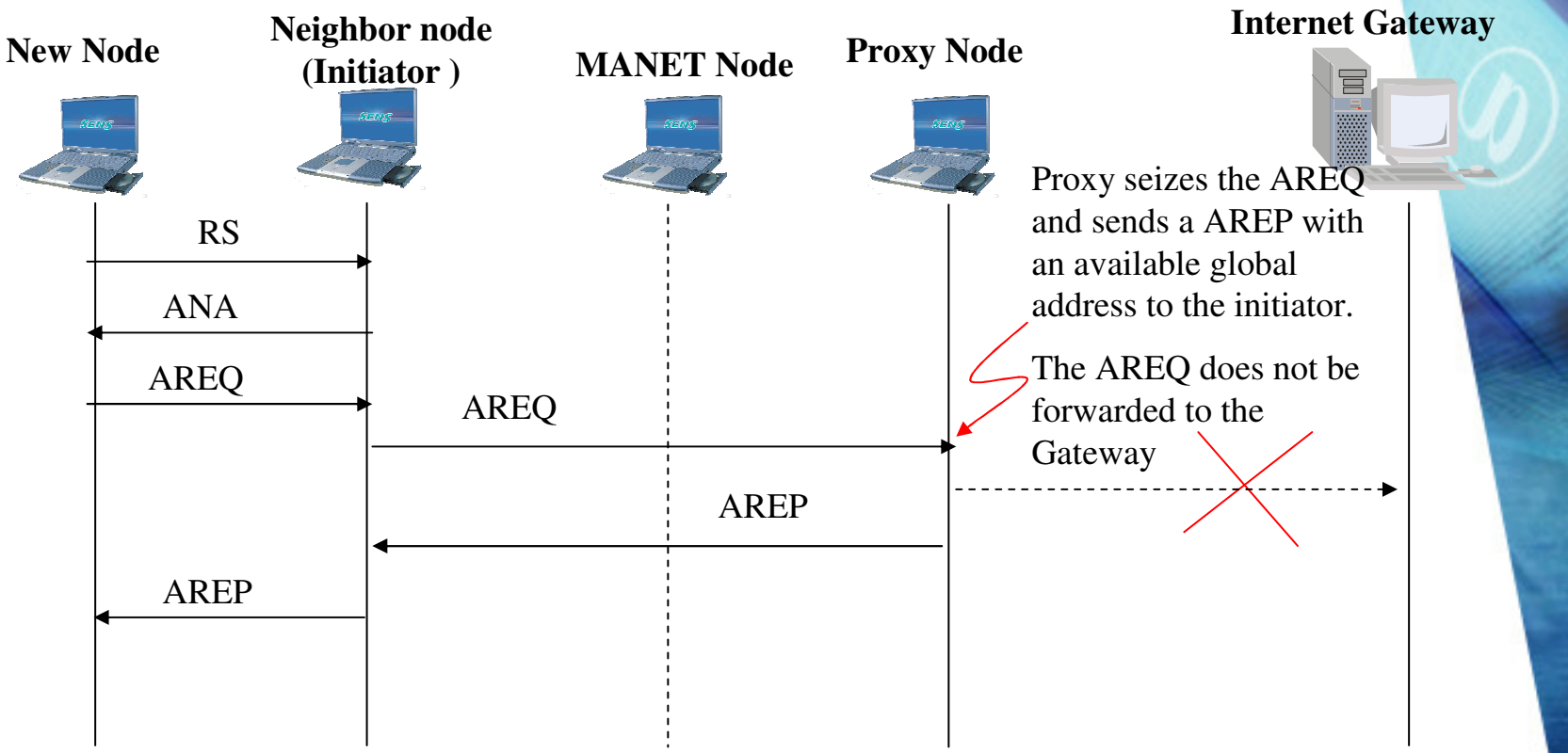
Address Auto- configuration in MANET (6)

- **Case 3 : There are some proxy nodes within one-hop distance from the initiator**



Address Auto- configuration in MANET (7)

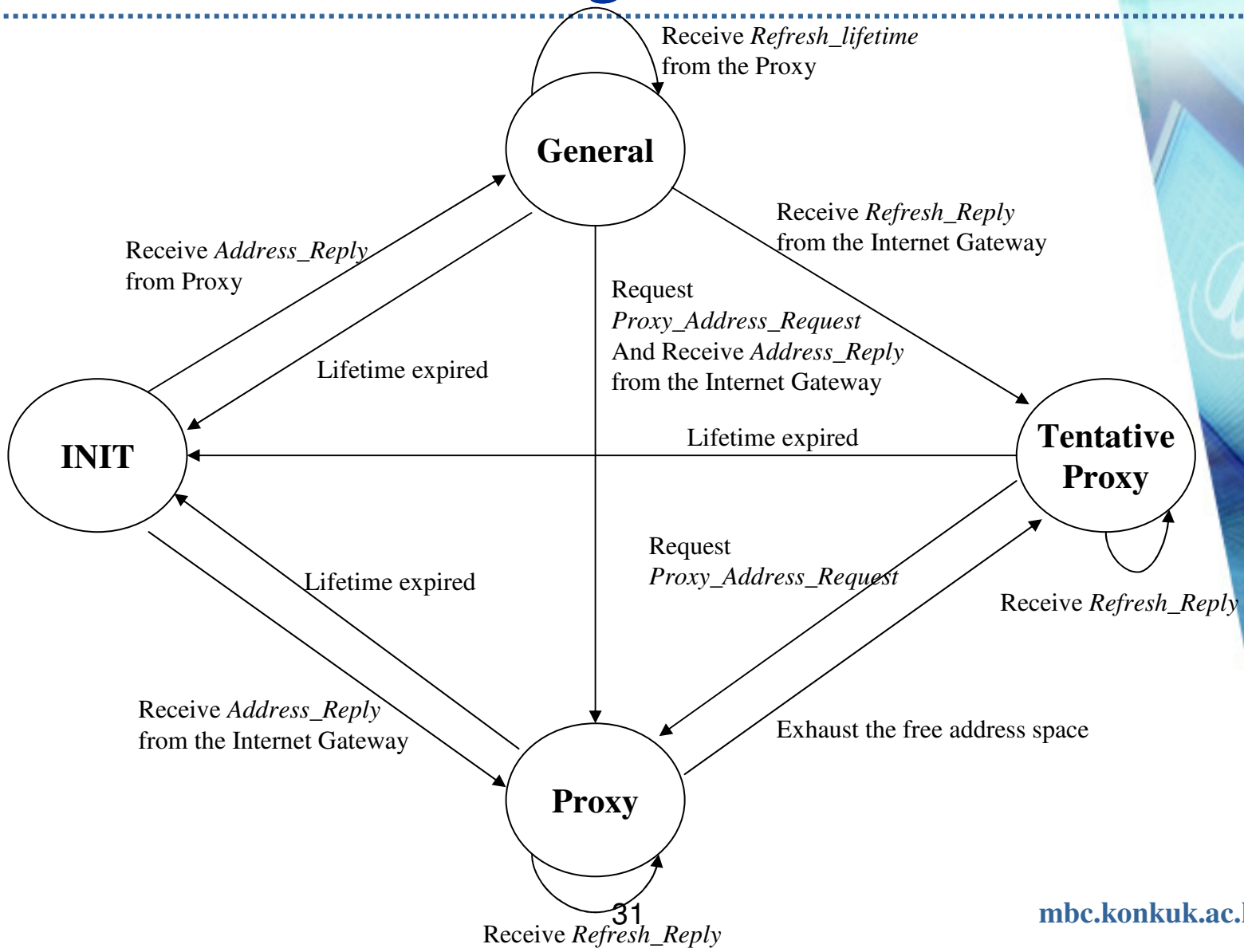
- **Case 4 : If any proxy exists in the path from the initiator to the Gateway**



Allocated Addresses Management

- ***The Internet Gateway should do the address management to prevent the loss of addresses.***
  - The proxy node should send Address_Refresh message to the Gateway before the end of its address lifetime.
  - Then the Gateway reply with Refresh_Reply message.
  - If no Address_Refresh, the Gateway multicasts the Refresh_Request message using the proxy- scope multicast address to the ad- hoc network.
    - all bits in Host ID of destination address are set to 0.
    - all nodes that have the identical Proxy ID with the requested destination address must receive the packet and respond to the Gateway.
  - If no answers, the Gateway removes the allocated address. This address space can be allocated to the other nodes later.
  - If any answers, the Gateway select a tentative proxy node among the responding nodes and sends Refresh_Reply message to the tentative node.
    - Tentative proxy must send periodic Address_Refresh messages to the Gateway. It cannot allocate addresses to other nodes.

State transition diagram of MANET Node



Conclusion

- *We have presented the method for the stateless/stateful auto-configuration of IPv6 global address for the scenario where Internet Gateway is available in the Multi- hop Access Networks*
- *Our ideas provide to effective auto- configuration mechanisms for WMN and Mobile Ad- hoc Network*
- *Our ideas is applicable to all Multi- hop Access Networks*

Thanks!

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