Active source routing for ad-hoc network: seamless integration of wireless environment

1. Introduction

Active networking is the emerging technology that will provide new network environment where lots of potential applications can be enhanced and developed. Current IP network is somehow good at simple packet forwarding, but it desperately needs some flexibility to support QoS and has to meets some restraint in certain environment. Active packets allow many functionality with great flexibility, however way too slow for data forwarding. To realize best performance in wireless environment, it is possible to hybrid both of approach and to take advantage of it.

We do have a variety choice of wireless environment depends on application such as regular cellular network, ad hoc network and sensor network. It is certain that each case should have different approach and any single protocol cannot match heterogeneous requirement for each network at this point, even though universal protocol for ubiquitous networking may finally evolve based on IP. However we also need to take into consideration of integration of such different network as a first step toward ubiquitous networking.

2. Routing methods and scenario

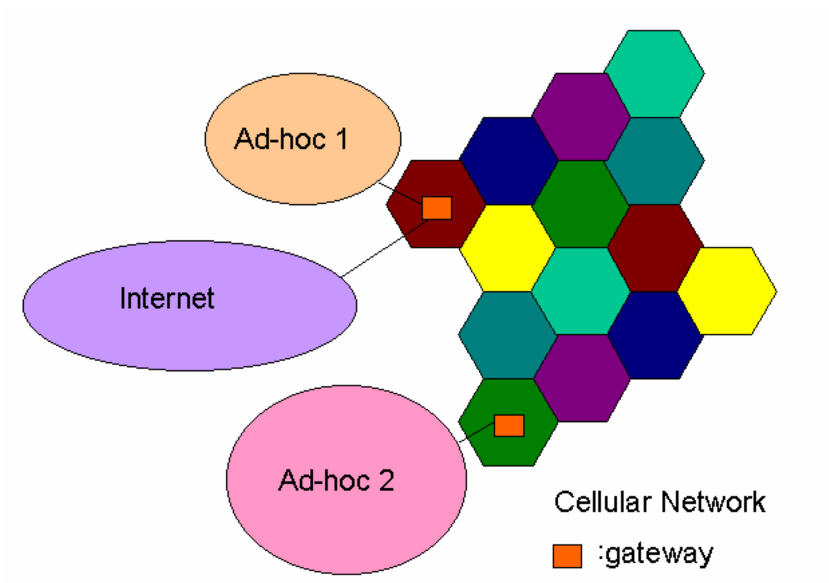

Figure 1. General topology of wireless network environment

2.1 Cellular network.

Mobile IP (RFC 2002), a standard proposed by a working group within the Internet Engineering Task Force, was designed to solve mobility problem by allowing the mobile node to use two IP addresses: a fixed home address and a care-of address that changes at each new point of attachment. Home agent and foreign agent are taking care of these addresses. Packet encapsulation and tunneling are the main idea of performing routing between HA and FA.

However, Mobile IP is not fit well into micro mobility situation. Frequent handoffs of mobile nodes bring to the result of high latency and disruption. To handle this micro mobility problem, several approaches are proposed such as cellular IP, HAWAII(Handoff Aware Wireless Access Internet Infrastructure).

Applying active functionality into the base stations which operate as foreign agent and gateway for ad-hoc network can reduce overhead of packet, maintain traffic more environment aware way, and handle micro mobility problem. This topic itself is huge and left for future research.

2.2. Ad-hoc network

Ad hoc networks are self-organizing, mobile wireless communication networks without infrastructure support. They operate in completely distributed manner and are independent of pre-existing network infrastructure. Each network node operates as a router and cooperates with other node to forward traffic to its destination on peer-to peer basis. There is s lot of space for adopting active network technology due to the nature of ad-hoc network.

Although a significant amount of research has been done on ad hoc routing, these protocols neither scale nor function well on the Internet. However, for many applications it is desired that ad hoc network is connected to the Internet. Therefore interconnecting functions between ad hoc network protocol and IP network are required. This functionality can be addressing, gateway discovery and selection, and heterogeneous routing.

Active packet can be applied as a control path packet that maintains path information, detect degree of node movement, and decide retransmission when packet loss occurs. Data packet is delivered in passive mode.

2.2.1 Ad-hoc Active source routing

A lot of ad hoc networking protocol has been developed and can be categorized table-driven routing protocol such as destination-sequence distance-vector(DSDV) routing, clustered gateway switch routing(CGSR) and source initiated on-demand routing protocol such as ad hoc on-demand distance vector(AODV) routing, dynamic source routing(DSR).

Those protocols are designed to support routing inside ad-hoc network itself, and do not consider Internet access. In order to maximize benefit from active functionality and realize seamless access to Internet, I propose active source(ASR) routing.

ASR is consisted of control packet in active mode and data packet in passive mode. Control packet is active packet that sets up the route, maintain the route and update it. Initial route selection is based on dynamic source routing, however after route is selected, control packets proactively maintain optimal route and prepare sub optimal route for temporary detour route until new optimal route is set up when data packet loss is detected. In addition to this functionality, ASR can monitor movement degree of ad-hoc network and perform appropriate packet modification to reduce packet loss and retransmission. To minimize control header size, Using dynamically assigned Tag instead of IP.

Route selection (Internal traffic): similar to dynamic source routing(DSR)

1. Source generate route request packet destined to N10 and broadcast it to the neighbor nodes.
2. Neighbor nodes check their cache whether they have valid route to N10 or not. If they have route to destination, they send back route reply packet to source. If not, broadcast until they find valid route information in cache or to the destination.
3. Once, source receives reply packet, source chooses optimal route depending on hop-count. Caches along the routes are updated.
4. In order to maintain traffic while optimal route is fail and reconfigure new optimal path, nodes should maintain sub optimal routes information depending on mobility degree of ad-hoc network. Sub optimal route can be decided in order of the most difference comparing to optimal route. If it is the case that strategic node is lost and even sub optimal nodes are out of use, wait until control packet set up new route.

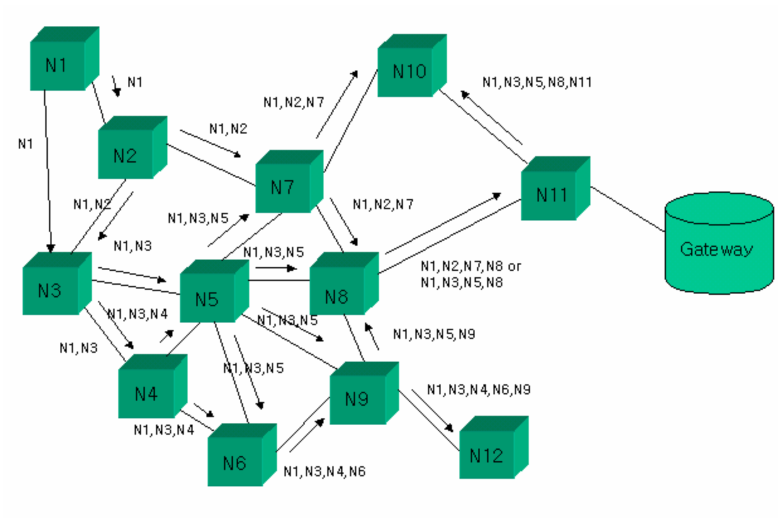

Figure 2. Building of the route record during the route discovery

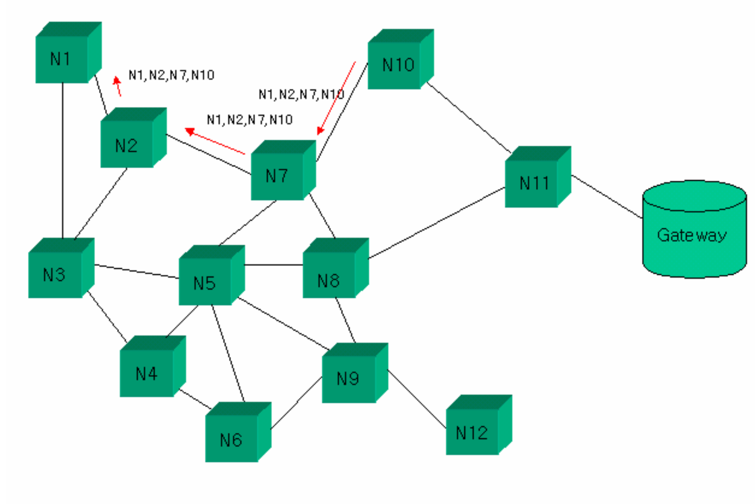

Figure 3. Propagation of route reply with route record

Seamless combination of ad-hoc and cellular networks will be important since the applications in both networks will merge. Users will want to move freely in ad-hoc and cellular networks and utilize the best possible service. For the combination of mobile and ad-hoc networks, flexible gateways and addressing schemes, which cope with the fast-changing nature of ad-hoc networks, are needed.

Internet Access (access through gateway)

1. Ad-hoc node requests Internet access through gateway. Node generates route request packet destined to gateway and broadcast it to the neighbor nodes.
2. Neighbor nodes check their cache whether they have valid route to gateway or not. If they have route to gateway, they choose that route to gateway and request packet follow that route. If not, broadcast until they find valid route information in cache or to the gateway. Gateway should broadcast periodically to update ad-hoc node that can reachable to it.
3. Payload of that Internet access request packet contains IP address of target server. Gateway translates that information and send request to the target IP address using current IP routing. IP packet has gateway IP address as source address and target IP address as destination address. Ad-hoc routing record is stored in gateway cache combined with requested target IP address.
4. Once requested IP packets arrived at gateway, they are modified to follow ad-hoc routing. IP header is deleted and formulate new data packet with small header that have ad-hoc routing information.
5. In order to maintain traffic while optimal route is fail and reconfigure new optimal path,

nodes should maintain sub optimal routes information depending on mobility degree of ad-hoc network. Number of sub optimal route the nodes are hold is depends on active control packet

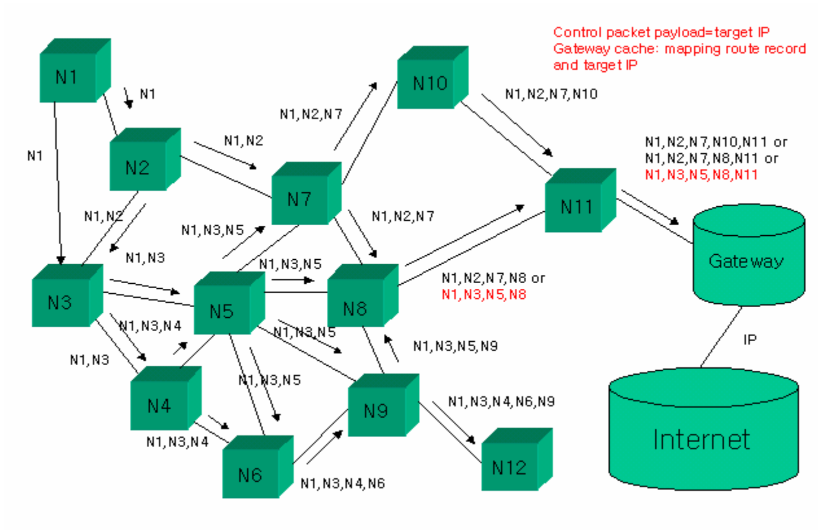

Figure4. Building of route record while Internet access request packet forwarding

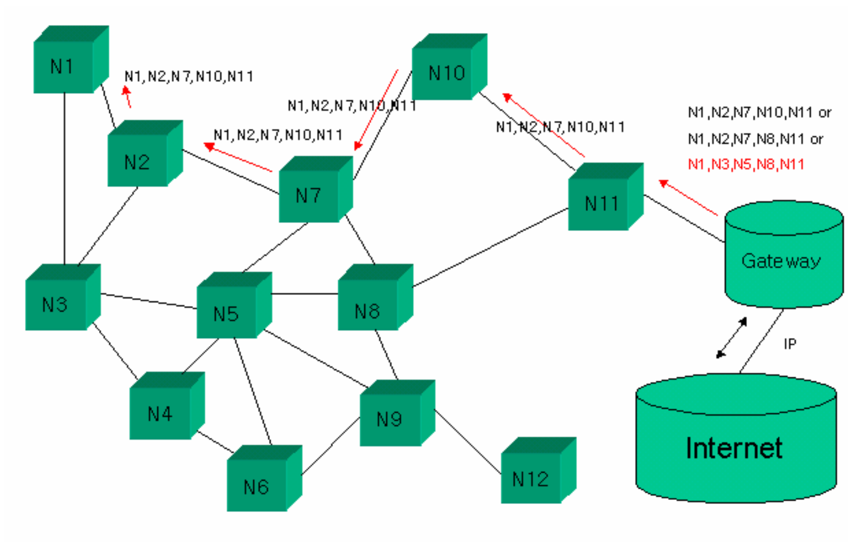

Figure 5. Requested IP packets are modified and forwarded to destination

2.2.2 mobility management and route update

In the mobile ad-hoc network, data routes are frequently changed and the request for route reconfiguration frequently occurs because of movement of mobile nodes. As the result, transmitting data is lost. Reliable data transmission is more difficult when the mobile nodes move continuously and faster. In order to solve such problem, every mobile node holds cache information for certain amount of time in soft-state fashion. If data loss is detected by any nodes between source and destinati on, node request retransmission from data cache of previous node and buffer the data flow until retransmission is completed. If the forward node toward destination is lost(unreachable), node take detour route while source is searching for another optimal r oute.

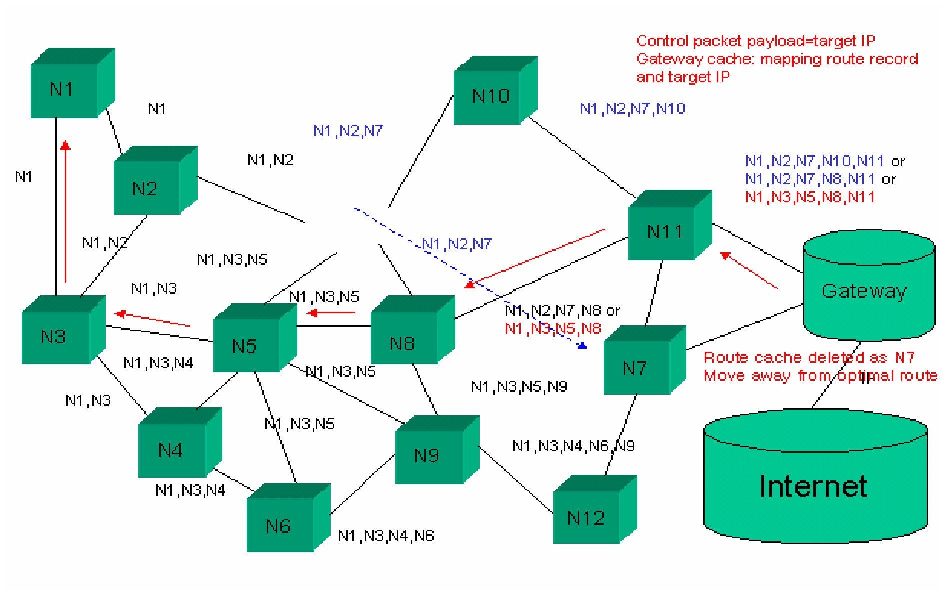

Figure 6. Node loss by movement and choosing sub optimal route (Ideal case)

2.2.3 Movement degree and modification of data packet

If mobility degree increased, probability of packet loss is also increased. In such case active control packet receives warning message and adaptively reduces data packet into more small size to minimize the chance of data packet loss. It is performed any region where frequent data packet losses are detected or frequent control packet updates occurs.

2.2.4 ASR packet format

ASR packets are divided by its functionality and identified by active type header. Routing tag is used for routing and dynamically assigned tag ID is placed in order of route. Packet header becomes more simple by moving control functionality into the active codes.

Active type header is consist of **Route_Request, Route_Reply, Access_Request, Route_Update, Movement_Warning, NAK(retransmission)**, and passive data(null).

Route_Request: used when source node are perform route discovery

Route_Reply: used when destination node reply to source node after route discovery is completed

Access_Request: used when node request Internet access through gateway.

Route_update: After route is set up, update route itself or nearby route accessible nodes information that is used fast route discovery when route failure occurs.

Movement_warning: When data packet loss is getting worse or frequent updates which imply nodes in the route are going to become unavailable, this control packet prepare for route change or aggravated channel condition. By executing active codes, cache allocation and buffer size can be reconfigured.

NAK: If sequence number of data packet does not follow previously received data packet or checksum does not match, receiving notifies packet loss or error and send retransmission request packet.

Routing Tag	Active Type Header	Sequence# Payload Checksum

Figure 7. ASR packet format

Payload contains data in passive data packet and active code in active control packet. Active codes modify ad hoc nodes how to handle data packet or maintain route.

2.3. Sensor network

Usually, energy constraints of sensor network is very severe and node itself does not have enough power to compute and execute active control packet and have small memory to store many data cache. However, this type of sensor network is much stable compare to mobile ad-hoc network. Therefore it should be treated differently from mobile ad-hoc network.

Complex optimal path computation is executed at gateway and that can make easily construct and maintain ad hoc network. Path selection depends on information sent by ad hoc node. Once ad hoc node send such information to representative ad hoc node it can integrate it or just send back to gateway, then gateway perform appropriate metric calculation for path selection on demand.

2.4 Partitioning problem

Partitioning is one of problem that ad-hoc network faces due to its nature. Once partitioned portion of network is formulated and becomes unreachable, there is nothing to do left for those portions. To prevent this event, there should be some sort of scout node that periodically patrol whole ad-hoc network area and, works as the bridge between two separated portions in case of partitioning event.

2.5 Security

Security in ad-hoc network should be stressed in data encryption and protection area because data packet traverse through other ad-hoc nodes. If data packet modification should be processed,

3. Implementation and performance evaluation.

Practically, simulation seems to be best evaluation tool for such a complex unpredictable network environment. By doing that, I can see how ASR performs compare to other solutions with the expense of what resource. Unfortunately it is beyond my ability at this point, and leave it for the further research.

4. Conclusion

Future networks will offer seamless and ubiquitous services, so that the user may even not be aware of the existence of different radio access networks. A main issue we address is hand-over between different wireless access technologies. To achieve this goal, Active Routing Protocol(ASR) for ad-hoc network is proposed. It utilizes active network technology as a adaptive control path controller.