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ผลงานวิจัยที่ได้รับการตีพิมพ์เผยแพร่

1. **N. Srifa**, C. Pornavalan and R. Varakulsiripunth, **"A Policy Based Negotiation Protocol for Services Agreement in Mobile Ad Hoc Networks"**, In Proceeding of International Conference on Information, Communications and Signal Processing (ICICS 2005), pp. 143-147 Bangkok, Thailand, December 2005
2. C. Pornavalai, **N. Srifa** and R. Varakulsiripunth, **"Designing of Policy-based Negotiation Protocol on MANET"**, In Proceeding of International Symposium on Communications and Information Technologies 2006 (ISCIT 2006), Bangkok, Thailand, October 2006

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A Policy Based Negotiation Protocol for Services Agreement in Mobile Ad Hoc Networks

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Abstract—**In this paper, we have proposed an approach of negotiation protocol for services agreement between two wireless nodes in ad hoc networks. Protocol principles are based on peculiarities of mobile nodes and mobile users on MANET, i.e., user autonomy, node functionality and resource management. Mobile users can use this negotiation protocol for defining its network functions in MANET based on their policy. Service level agreements between two wireless nodes can be renegotiated depending on current user's application requirements and available resources. Protocol is designed to be able to negotiate on many parameters such as route, link bandwidth or QoS. We also present a scenario in MANET to show the effectiveness of our proposed protocol.**

Keywords—**MANET, negotiation protocol, user policy.**

I. INTRODUCTION

At present, the high progressive technology leads to the creation of modern network such as Mobile Ad hoc Network (MANET) [1]. Advantages of this network are rapid deployment, robustness, flexibility and support for mobility which is suitable for the environment like, battlefield or disaster recovery; moreover it can be used anywhere and anytime. The specific characteristics of MANET are the arbitrary and dynamic combination of mobile nodes or mobile hosts that have rapid and random alterations. Therefore, it is considered as multi-hop topology with no network infrastructure and no centralized administrator. The limitations of MANET are inherited from those in the case of wireless link; limited bandwidth and high error rate, resulting in the difficulties in protocol development.

In another aspect, MANET has a problem with mobile node equipments on the limitation of hardware resource sush as CPU, memory, battery, and bandwidth. But these resources are usually consumed as shared resource in MANET to forward information of other users, to exchange routing information, etc. Each user does not have ability to manage its resources, though he/she is the owner of the mobile equipments or resources. Users should have the right to utilize the resource as he or she would like to, such as, the ability to allocate the remaining resources from each user to the network, the ability of unwilling to participate in exchange routing information of information forwarding.

According to the characteristics of multi-hop topology of MANET, information transfer is needed to proceed from one node to the adjacent node in hop-by-hop manner. Therefore, the agreement between node and its neighbor node is required. Consequently, a protocol to be used by each user in the network is needed to fulfill the requirement for both node and its neighboring node. This protocol should provide the information for each user to satisfy the provided services from each other and also provide the allocation of limited resources wisely by using user policy.

Therefore this paper presents a negotiation protocol for each wireless node to agree with its adjacent nodes for service agreement. We propose several types of attributes to indicate requested service value from its neighbor node. The node that provided services, checks requested attributes and values, with its policy and replies result, accept or reject or re-negotiate, to its neighbor node.

The remainder of the paper is organized as follow. In section II, recites related work both wired network and wireless network. Section III presents negotiation protocol overview, including all protocol's components and messages. In section IV, we describe protocol with a scenario which details protocol messages usability. The last section is our future works and paper conclusion.

II. RELATED WORKS AND MOTIVATION

So far, the study of MANET mainly concentrated on routing protocol, power saving, QoS, and security. This paper would like to present MANET in the aspect of network autonomy and resource management. Due to MANET is constructed from the combination of each user who provides shared network resource which is different from wired network and infrastructure mode in wireless network, in which service provider provides network management and network services.

Therefore, we will compare several aspects between MANET and the Internet as it is used to represent the wired network and infrastructure mode of wireless network, because of its popularity on those networks in the subsection *A)*. The descriptions of the related works are in subsection *B)*.

A. Comparisons between MANET and the Internet

1). Mobile Node's Roles and Resources

There are two different node types on the Internet, those are 1) network edge or node (host) and 2) network cores (routers/switches). Hosts perform as the source or destination of communication whereas routers work for serving the applications of hosts by searching for the routes, store and forward data according to routing table. But in MANET, every wireless node has both host and router roles at the same time.

MANET resources such as processing unit, memory and link bandwidth are limited comparing to the wired networks. These resources belong to the owner or user of the mobile node on MANET. They should not be used in the uncontrollable manners by activities such as consuming a lot of CPU time for calculating another node route, using link bandwidth for forwarding other users data. These activities may not be directly useful to the owner of the mobile node.

Therefore in our opinion, mobile node should be able to manage its roles by weighting the functionalities that it wants to participate in the MANET and allocating its resource to each role varying its willingness based on its defined policy.

2). Autonomous System (AS)

On the Internet, autonomous system is a group of routers that managed by the same administration. In term of routing on the Internet, there are two groups of routing protocols.

a) Intra-AS routing protocol is used to find routes among the routers within the AS. Most of Intra-AS routing protocols find the best routes based on the metric such as hop-count, cost, and bandwidth.

b) Inter-AS routing protocol is used to exchange routing information between AS. Border Gateway Protocol (BGP) [2] is now the de-facto standard on the Internet for Inter-AS routing protocol. BGP exchanges routing based on the configured policy on the routers in the AS.

On the other hand, in MANET, users are not in the same administration control. They administer their mobile equipment by themselves. Therefore, a mobile node is autonomy. However, users need to maintain their connections via MANET to other users. We analogize a wireless node on MANET as an AS on the Internet.

With the above reasons, path management on MANET should be similar to Inter-domain routing more than Intra-domain routing. Administrator of ASs/mobile nodes should have right to manage their autonomy. Applying policy-based to MANET is a good solution to meet this aspect.

B. Related Research Works on MANET

All current MANET's routing protocols are modified on the existing routing protocols operating within fixed network. For example, Destination Sequence Distance Vector (DSDV) [3] is based on Bellman-Ford routing mechanism similar to RIP, and Global State Routing (GSR) [4] used link state algorithm. These routing algorithms for MANET are similar to Intra-domain routing. But no MANET routing protocol performs with policy-based routing protocol as BGP does. According to the discussion in Section 2.1.2, MANET routing protocol implementations should not follow Intra-domain routing. So MANET needs a new negotiation protocol to negotiate the exchange of routing information based on the policy similar to the Inter-domain routing protocol.

QoS is an important requirement for the MANET to interconnecting with wired networks that support QoS and for real time applications running on MANET. A Flexible Quality of Service Model for Mobile Ad Hoc Networks (FQMM) [5] attempts to propose a QoS model for MANET to take advantage of both IntServ [6] and DiffServ [7]. For applications with high priority, per-flow QoS guarantees of IntServ are provided. On the other hand, applications with lower priorities achieve DiffServ per-class differentiation. FQMM inherits advantages from IntServ and DiffServ. But it also gets inheritance aspects such as scalability problem from IntServ. IntServ and DiffServ are usually used in the corporate network that required the same administration domain. Because we consider each node in the MANET as an autonomous system, deploying IntServ or DiffServ required policy-based negotiation protocol in the MANET.

FQMM categorize mobile nodes into three groups: (a) Ingress nodes that classifying, marking and policing packets, (b) Interior nodes that forwarding data following DiffServ's Per Hop Behavior (PHB), and (c) Egress nodes which are the destination nodes. In FQMM model, all MANET nodes perform their roles as router and provide QoS for other nodes in the network. Acting FQMM's roles such as Ingress node and Interior nodes will put more surplus loads for these mobile nodes. Users should have their own policy for controlling their mobile node roles and manage consuming resource for each role.

The research in [8] and [9] have proposed algorithms to perform QoS routing. They cluster wireless nodes into many communities, composing of slave-node and super-node. Super-node will have too much load, because it must maintain all its slave-node's IP address into its routing table, and search a route in virtual route discovery phase for every path that pass its cluster. SRL algorithm suggests using any algorithms for electing super-nodes. We recommend that the election of super-node should be done based on considering the autonomy of each mobile node. Therefore we need policy-based negotiation between each mobile node when electing super-nodes. Also super-node should have authority for determining that it needs to join other nodes' virtual paths or not.

In this paper, we propose a negotiation protocol based on user policy by considering about above-mentioned MANET's characteristics. Our protocol has two main characteristic; 1) a mobile user has right to control their resources that are provided to their neighbors, and 2) a mobile user can choose to perform its preferable network roles, base on its policy.

III. Model Overview and Protocol

Our protocol is a new policy based negotiation protocol. Users negotiate with its adjacent node about service cooperation between two nodes. This protocol will satisfy users by allowing them to enforce their network activities with policy. This negotiation protocol design mediates to MANET constrains which described in section II. The protocol has 3 phases.

In the first phase, a mobile node negotiates with its adjacent nodes to be the neighbors. Mobile node can get adjacent node's IP address by using multicast hello packets. After that, each node creates a neighbor table for maintain adjacent node's information such as neighbor node's identity, information and services to be negotiated.

In the next phase, these two nodes use the negotiation protocol for negotiating services between their neighbor nodes. Each requested service is described by its attributes. The node, that received requested services, will examine requested services' attributes with its policy for decision about exchanged service. Node will negotiate using protocol for satisfying request and acquiring service from its neighbor node. When the situation changed, wireless node can use negotiation protocol again to change its requirement. If a node wants to stop negotiated service, it will send end connection message.

Then the last phase is started. After node sent end connection message, it terminates all MANET connections, clears neighbor table data and releases all hold resources. Node that received end connection message will delete information about sent node from its neighbor table and release resource that reserved for that node.

A. Protocol's Components

In our proposed protocol, there are three components those are 1) Node Exchange Information (NEI), 2) Service Exchange Information (SEI), and 3) User Policy. Mobile nodes use *NEI* and *SEI* to exchange node and services negotiation information respectively. For example, *NEI* is used by mobile node for advertising information about itself to neighbors, and requesting additional information from its neighbors for making decision. It composes of many attributes that describe detail of the information that is important to the mobile node on MANET. We categorize *NEI* into two groups which 1) *Mandatory NEI* and 2) *Optional NEI*. Mobile node must send *Mandatory NEI* such as "Host's Identification", to all neighbors. *Optional NEI* is used for asking addition information from its neighbors. Examples of *NEI* and their attributes are as the following.

- **Group identification**: Mobile nodes in MANET can join into a group for the purpose such as users in the same company gather into a group for serving company applications. Example of attribute for this *NEI* is "*Group name*".
- **Host's identification**: A mobile node can serve to some nodes with special priority. To do that it needs to know its neighbor node's identification. In this example, Host's Identification's attribute may be "*Mobile node's IP address*" or "*Mobile node's MAC Address*"
- **Mobility speed identification**: Mobile users can set a policy to prefer the neighbors with slowly moving node rather than fast moving node, because of their connection stability. Attribute of this mobility speed identification is "*Mobility speed rank*". Its values might be "*Slow, Normal, and Fast*".

Mobile nodes can use *SEI* to request for service from its neighbor nodes. Examples of *SEI* and their attributes are as the following.

- **Routing service**: This is an important service on MANET because of it is used during MANET route discovery process. In case of a mobile node allows to forward routing information to other nodes, it implies that mobile node agrees to let other mobile nodes' data to traverse through it. Due to all current MANET routing protocols do not support for this feature, routing with policy-base. For this approach, we must modify existing routing protocol to support policy-based. A primary attribute of routing service is "*Forwarding routing information*". Its possible value is either "*Forward*" or "*Not forward*".
- **Bandwidth reservation service (BRS)**: A mobile node uses amount of its bandwidth for forwarding its adjacent nodes' data. It shares its bandwidth for other nodes. In the other hand, mobile node sends its data by using another node's bandwidth together. BRS is a service for reserving neighbor nodes' bandwidth for forwarding mobile node's data. Examples of BRS' attributes are "*Bandwidth Quantity*", "*Amount user for this bandwidth*".

User Policy is used to define all mobile nodes decisions and behaviors. There are four components in the *User policy* those are 1) *Policy agent*, 2) *Resource Manager*, 3) *Policy database (rules)* and 4) *Neighbor table*, as shown in "Fig. 1". Policy agent is a coordinator for other policy components. It sends and receives messages with other mobile nodes. After that it interprets the messages and sends the signal to the other components. Resource manager has ability to control all mobile node resources such as bandwidth. It manages allocated resources for its entire neighbor nodes. The next component is policy database or rules that are set by user for controlling all network activities of that mobile node. And the last component is neighbor table that created by policy agent when mobile node successfully negotiated with its neighbors. Its contents are "neighbor node name", "negotiated service" and "negotiated service value".

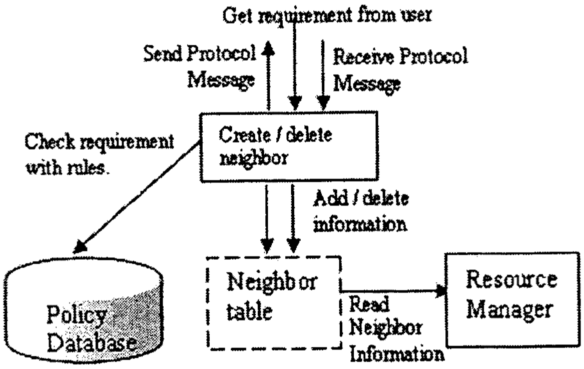

Figure 1: Components of user policy.

B. Protocol Message

We divide protocol message into 4 groups by its usage as following.

1) Set up neighbor node: Protocol is started when a node sends message to its adjacent node for requesting to be a neighbor and advertising its NEI. If adjacent node accepts or rejects that requirement, it finishes at this phase. Messages in this phase composed of following.

- *Hello (node_identifier)*: Mobile node multicast hello message to discover all its adjacent nodes' IP address.
- *Req_NBR (Mandatory NEIs, Mandatory NEI attributes, Mandatory NEI attribute values, adjacent_node_identifier)*: This message is used to ask node with adjacent node identifier to be the neighbor. It also sends its *Mandatory NEI* to this adjacent node.
- *Res_NBR (Mandatory NEIs, Mandatory NEI attributes, Mandatory NEI attribute values, requested_node_identifier)*: Node that received Req_NBR uses this message to response to the requested node to accept or reject the request. To accept the request it sends its *Mandatory NEI* value in this response message, otherwise with null value.
- *Req_NEI (Optional NEIs, Optional NEI attributes, request node's Optional NEI attribute values, adjacent_node_identifier)*: Mobile node uses this message for asking more information about its neighbor nodes.
- *Res_NEI (Optional NEIs, Optional NEI attributes, Response node's Optional NEI attribute values, request_node_identifier)*: Responded node informs its *Optional NEI* value to adjacent node with this message.

2) Negotiation for Services: Mobile node uses this message type for negotiated SEI between two neighbor nodes.

- *Req_SEI (SEIs, SEI attributes, request SEI attribute values, offer SEI attribute values)*: Mobile node, which wants to negotiate services with its neighbor nodes, will send this message for informing its request service. *SEIs* field is used to define the desired service of mobile node. Each *SEI* has many attributes. The requested and offered attributes and its values are also included in this message.
- *Res_SEI (SEIs, SEI attributes, request SEI attribute values, acceptable SEI attribute values)*: Mobile node sends this message to response to its neighbor node's request *(Req_SEI)*. Content of acceptable SEI attribute values fields are values that responded node has ability to serve the requested node.

3) Maintain Neighbor: Node needs to know about its neighbor's status. If the neighbor node was down, cause to waste holding resources for that node. Therefore maintaining neighbor state is required. We proposed to maintain neighbor node status by using keep-alive message.

- *Keep-alive (interval)*: Keep-alive message was sent periodic to all its neighbors. If a node does not receive keep-alive from its neighbor with in a timeout, three times of the interval, it will assume that its neighbor was down. It then releases all holding resources for that node.

4) End connection: When a node wants to cancel all negotiated services or finish using services, it will send end connection to its entire neighbors. Neighbor nodes will release all allocated resources. All end connection messages are sent with code format to explain the reason to terminate the neighbor relation.

- *End_Connection (code)*: Terminate connection code show cause of termination.

MANET characteristics such as limited resources, rapid topology changes would make end-to-end negotiation not scalable and protocol overhead very high. We believe that more scalable solution would be the protocol that can negotiate only between each pair of neighbor. In our proposed protocol, negotiation is done between adjacent nodes only, and after two nodes finish negotiation, only keep-alive message is required for maintaining their negotiated services. Therefore, we can keep the protocol overhead low; at the same time provide more scalability.

IV. SCENARIO

In this section, we describe function of our protocol using the following scenario. An example MANET has 9 mobile nodes that run DSR [10] routing protocol. Assume that there are 4 source node, i.e., A1, B1, C1 and D1 want to connect to destination A2, B2, C2 and D2 respectively.

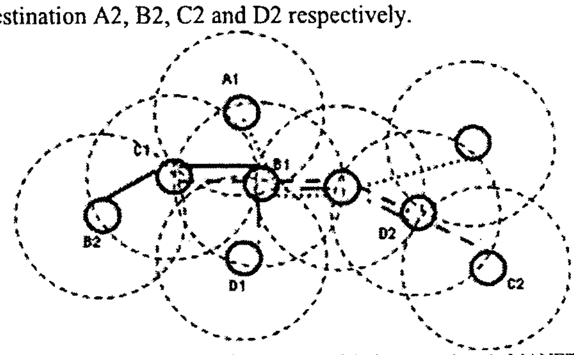

Figure 2: An example of mobile nodes and their connections in MANET.

Connections are started when nodes searching route that learned by routing protocol, to their destinations. Suppose that the routes used in the all four connections are shown in "Fig. 2". The bottleneck will occur at node B1. It uses a lot of resources for transferring data of other users. For solving this problem, supposed that all nodes run our proposed negotiation protocol for controlling their service under control of their policies.

Node B1 sets its policy as following rules.

- 60% of resources for its application and the rest for other nodes in network.
- For remaining resources
  - Lowest priority is assigned to all nodes in MANET.
  - Offer low priority to its neighbor nodes.
  - Prefer to serve neighbor node that have the same group name with medium priority.
  - Prefer to serve neighbor node with high priority if that neighbor node also offer high priority service.

After all nodes get their routes, every node set other nodes with lowest priority. Due to all nodes discover their adjacent nodes by using routing protocol; they do not need to use "*Hello Message*" to discovery again. Node A1, C1 and D1 want to get better service than lowest priority so they send *Req_NBR* message with their node identifications to B1. Resource manager of B1 checks for the remaining resources and found that it can serve to all requests. B1' policy agent then sends *Res_NBR* with its identification to them to accept the request, and changes these node priorities to low priority. Then these four nodes' policy agents create their neighbor tables that contain their neighbors' information. A1 user knows that B1 is in the same group, so it sends *Req_NEI* to B1 to inform its group name. After B1 receives this message, it adds A1's group name into its neighbor table and changes A1's priority to medium. An authentication may be necessary at this step to ensure that A1 did not spoof its own group name.

When B1 wants to send its data to B2 through C1, It offers high priority to C1, and asks for high priority from C1 as well. C1 then checks its policy and accepts B1's requirement, supposed that C1's policy allowed to do so. Both B1 and C1 then change each priority from low to high.

V. CONCLUSION AND FUTURE WORKS

In this paper, we proposed a new approach of negotiation protocol on MANET. Our protocol has the motivation from the autonomy of each node in the MANET. With our protocol, users have ability to control their resources and network activities through their policies. All MANET resources are used to satisfy the resource owner's satisfaction while allowing for negotiation to serve other users. Performance analysis of our proposed protocol will be done using simulation in our future works.

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Designing of Policy-based Negotiation Protocol on MANET

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Abstract— **Due to many unique characteristics on the MANET environment such as node's autonomy, highly limited and shared resources, dynamic topology, etc. And these characteristics introduce to the new MANET aspects such as node autonomy, node's roles and resources. The needs for each node to control its resources and roles participated on the MANET is increasing. In this paper we proposed a design of policy-based negotiation protocol that users are able to control their resources. We also describe the design goals, its design principles and negotiation process of our proposed protocol.**

I. Introduction

Mobile Ad Hoc Network (MANET) [1] is constructed by a number of MANET nodes. They connect to their adjacent nodes via the wireless communication such as wireless LAN (IEEE 802.11). Advantages of MANET are rapid deployment, no infrastructure, robustness and support for node mobility. Usually MANET stations are light weight mobile devices such as laptop or PDA. These devices have limited resources such as battery life time. And the general data-link protocol for these devices which is IEEE 802.11 has a number of limitations such as distance, data transmission bandwidth, etc. Moreover, MANET topology will be changed frequently due to node mobility during node life time. These are constrains that we need to consider when designing a protocol that work well in MANET environment.

Furthermore, MANET transfer data in multi-hop manners which means that source node send data to its adjacent node, and data will be relayed to the next node over and over until it reaches destination. Therefore, to be participated in MANET environment, the intermediate nodes must spend their resources to serve other nodes' applications as well. Resources consuming in this manner may not be satisfied by station owner who forwards a lot of other nodes' data.

There are many aspects in the MANET such as node mobility, limited resources, and unreliable data link layer protocol. These aspects are quite well studied in many research litterateurs. In this paper, we introduce two new aspects node autonomy and manageable node roles and resources. We proposed the solution for these aspects in the previous paper [6] by creating the policy-based negotiation protocol for MANET.

Hence, in this paper, we propose the design and its principles for policy-based negotiation protocol and its framework to allow users to control their devices activities and consuming resources as their desires. The proposed protocol is also designed to cope with many constrains of the MANET environment, such as dynamic topology, high error rate transmission, etc.

The remainder of this paper is organized as follow. In Section 2 we present our motivation for this protocol and the related works. Our protocol design goals and principles are described in Section 3. In Section 4, we present the design goals, and its principles and some detail of the proposed policy-based negotiation protocol including its components and messages. The last section contains conclusion and our future works.

II. Motivation and Related Works

In this section, we will briefly describe our MANET aspects and motivation of proposed protocol by comparing MANET with the Internet and survey several researches on MANET protocol and energy consumption. The more detail can be found in our previous work in [6].

2.1) Motivation

Because of the Internet is the most popular network, its architecture was designed carefully for scalability, stability and etc. Comparing MANET to the Internet, we found two special additional aspects of MANET that must be considered for designing MANET protocol. Hence, these two aspects are 1) node's autonomy and 2) node's roles and resources.

Node's autonomy: each MANET node belongs to each user. So we can analogize a MANET device to an autonomous system on the Internet. Users should have rights to control their own devices. But today we do not have any protocols that allow users to administer their MANET devices' network activities. In the Internet autonomous system, we used a BGP [7], policy-based routing protocol, to manage Internet routes. In the same way, we also apply policy-based protocol to MANET for allowing users to manage their MANET devices.

Node's Role & Resource: There are mainly two roles for data transmission on the Internet, i.e. host and router. Host is a source and destination of data transfer while router relays data from source to destination. Relaying data will consume a lot of energy which is the strictest resource, comparing to the idle state as describe in [8], In Internet, each device has individual role. But in MANET each device must play both roles.

Therefore users must provide and share resources such as computing unit, storage, and network bandwidth to the MANET. Generally MANET devices are mobile devices also these devices do not have such excessive resources. Each roles of MANET need the different amount of resources. These mobile device resources are consumed by their own applications or serving the other applications such as computing route, relaying data. To manage their own resources more efficiently, users should have the ability to control consuming resource by node's acting roles.

2.2 Related works

There is a possibility to use MANET as gateway to the Internet. Internet applications will produce large amount of data that injected into the MANET. It must support these applications data such as high content web page, multimedia or real-time application. Therefore, provide QoS for MANET is an essential solution for improving network performance. There are two famous QoS providing protocol on the Internet, 1) IntServ [2] and RSVP [3] and 2) DiffServ [4]. But they cannot be applied to MANET directly. FQMM [5] proposed a QoS model for MANET by getting advantages of IntServ, per-flow guaranteed for high priority applications, and DiffServ, serve per-class QoS for lower priority applications. FQMM still reserves QoS along the path. Hence, it needs a large number of messages for preparing QoS in a dynamic topology of MANET. Usually IntServ and DiffServ are deployed in the same administration domain. But as described earlier, in the MANET, each node exhibits as autonomy. Therefore FQMM cannot be used to manage resources of each users's own resources. In addition, it could not cope well with the dynamic topology changes of the MANET.

Therefore, it is clear that we need a protocol that allows users to administer their MANET devices and to negotiate with other users on the MANET to manage its own resources and request other users' resources.

III. DESIGN PROTOCOL

As already mentioned, MANET has many special characteristics due to its wireless physical link such as high data lost rate, low bandwidth capacity and node mobility. The protocol should be designed considering these characteristic of the MANET. We studied many of MANET researches and defined our four design goals that cope with MANET characteristics in subsection 3.1. We also introduce three mechanisms or principles for achieving these design goals as describes in "Design Principles" subsection.

3.1 Design Goals

1). Minimize protocol overhead: Due to limited resource of MANET, minimize protocol overheads is an important aspect in MANET. Number of protocol exchanging messages is considered as one of the protocol overhead. The information of state that mobile node must retain can be determined as the overhead of MANET as well. Because negotiation protocol will add extra overhead to the node itself and to the MANET, minimizing it would be the one of the important design goals.

2). Tolerate to dynamic topology and routing: MANET topology tends to be changed very frequently due to mobility of the users. Since user can connect to MANET arbitrarily which causes the node to come up and down at difference places, therefore routing on the MANET tends to be updated very frequent as well. The protocol that is too sensitive to the dynamic topology changes will produce a lot of exchanging messages, which affect to the resources such as network bandwidth and energy consuming.

3). Cope with the unreliable lower-layer protocols: MANET data link protocol has a high error rate data transmission because of nature of wireless link. And it is sensitive to the interference. Also sending messages may be lost without any notification to the sender. The network layer protocol, IP, does not provide any reliable transmission mechanism. The TCP, reliable transport layer protocol, on the other hands, is not suitable to MANET environment because of its high overheads that effect to the performance of the network.

4). Independent of routing protocol: In [6] we proposed that each MANET node exhibits as an autonomous system. Node's owner should have rights to administer their devices, including the choice of the routing protocols. The negotiation protocol should be flexible by separating the routing and negotiation, and be able to run on any routing protocols that nodes in the MANET agree.

3.2 Design Principles

1). Negotiate only with the adjacent nodes: Whole path negotiation will produce a lot of message because of rapid changing of routing and topology. For example, if one of the nodes along the path was moving out, route recovery and re-negotiated process will be started again. Hence, we propose one hop negotiation approach, that MANET nodes only negotiate the requested services from its adjacent nodes, 1-hop neighbors. By using this approach, protocol will reduce unnecessary recovery message and tolerate to high changing topology and not rely on any routing protocols. Though the level of the services negotiated may not be as good as end-to-end negotiation, but with the highly adaptive network such as MANET, end-to-end negotiation tends to be interrupted more frequently.

2). Soft-state: The hard-state protocol needs explicit messages for informing the changes of the state. After negotiated, a node may allocate some resource for serving to the other nodes. If it loses a cancel message, this will waste the limited resource of MANET due to node in MANET can disappear by many reasons such as node mobility or lack of battery. Therefore, there are many advantages to implement soft-state and keep-alive message to MANET protocol. Two nodes that finish the negotiation must send keep-alive messages for maintaining the negotiated services. If they do not receive keep-alive message for a time period, they will release their allocated resources. Node can change to idle state and release all allocated resource faster than hard-state because of soft-state uses timeout to trigger the state stored on that node. Using keep-alive messages will consume a number of energy but this should be a worthwhile price to free the holding resources.

3). Best-effort negotiation: In high interference or high noise network, it may be difficult for a node to send packets to its adjacent neighbors. In this case, negotiated session will be broken because of lacking of keep-alive messages. Attempting to reconnect the negotiated session to that node may not be significant because provided services from that node tend to be unreliable.

On the other hands, in a very congested network, every node will compete for the shared resources such as bandwidth to send its own data. Anyways, competing for bandwidth on a wireless link depends on the media access protocols being used by the MANET nodes. If there is no such protocol and it is difficult to have a successful negotiated session between two nodes because of lacking of resources, the successful and negotiated services tend to be unreliable as well. Therefore, in the case, doing best-effort negotiation seems to be sufficient in the MANET environment.

IV. Protocol Overview

In this paper we modify our protocol components and the negotiation process from our previous published paper [6], we proposed definable User Policy, and two types of Exchange Information, Node Exchange Information (NEI) and Service Exchange Information (SEI). The NEI is used to exchange any essential information from its adjacent node to identify node's owner and SEI is used for requesting provided services from adjacent nodes. Each Exchange Information has its own attributes for describing their properties. User policy is used to collect defined rules and to control serving negotiated services. We describe detail of these our protocol component in subsection 4.1 and how these protocol components cooperate in the subsection 4.2.

4.1 Protocol Components

1) NEI: Each node has its own characteristics that can be described by using NEI. User may need this information from other adjacent nodes to make a decision for providing services during negotiation process. An example of NEI is node's movement that has speed and direction as its attributes. Such information can be used to justify the reliability of the services provided negotiated nodes. And node may update NEI during the session for providing the most recent information.

2) SEI: Users are able to negotiate their requested services by describing its required service and attributes via SEI. Generally SEI is the services for forwarding data such as bandwidth, delay or jitter. The SEI can be extended easily to include new services in the future. When two nodes completed the negotiation, they will allocate their resources for serving the negotiated services. These negotiated services may be changed or renegotiated because of the fluctuated resources.

3) User policy: Users are able to manage their resources by defining their requirements and decisions into their *User Policies*. It composes of four components *1) Policy Agent, 2) Resource Manager, 3) Policy Database (rules)* and *4) Neighbor Table*. Policy agent behaves as a coordinator for the other policy components by sending and receiving all controlling signal and user messages. Resource manager handle all mobile node's resources for serving to the negotiated services. For example, it manage queue for forwarding data of adjacent node. The next component is policy database or rules that are set by user for controlling all node roles. Neighbor table component is created by policy agent when mobile node successfully negotiation with its neighbors and it will be deleted after all negotiated service was canceled or time out. The figure 1 shows how these components interact with each other.

4.2 Negotiation Process

The proposed protocol will work in three phases. In the first phase, user will discover their adjacent nodes. This can be done by using existing mechanisms of MANET routing protocol's node discovery, such as AODV.

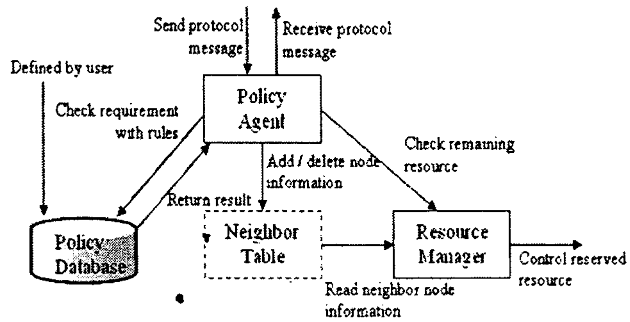

Figure 1 Interactions between protocol components.

The second phase is a negotiation phase. Before the negotiation will be started, users may need some authentication to prove its authenticity. This function is an option in our protocol. User can choose any authentication processes such as username and password to authentication its adjacent nodes. We do not describe the authentication process in this paper.

Users can define their requirement and decision rule into their *User Policy,* such as preferable services for some nodes that have some special characteristics. These node characteristics will be sent through NEI. Negotiation starts when node sends the request for a service or identifies itself and its attributes that describe service or node information via SEI and/or NEI to an adjacent node. This is a one hop negotiation approach as stated in design principle. Two negotiating nodes will negotiate for their desired services until their demands can be met as defined in the *User Policy.* To maintain negotiated session, keep-alive messages must be sent periodically. Users may negotiate more than one service from an adjacent node, or to multiple adjacent nodes simultaneous. Our protocol will attempt to negotiate as best as the network environment can support. The fail negotiation will be renegotiated again after its waiting time reaches back-off timer. If back-off time reaches to the threshold, protocol will stop the negotiation for this session.

The last phase is the termination phase. Although our protocol is soft-state protocol, we provide the process for releasing resources before timeout. Because soft-state must wait for timeout to restore its states, allocated resources may be not utilized efficiently, depending on the agreed timeout value. This mechanism is possible to introduce the higher network performance.

V. CONCLUSIONS AND FUTURE WORKS

In this paper, we present a design of the policy-based negotiation protocol on MANET. We describe its design goals and principles that cope with the strict environments of the MANET. With this approach, users have rights to control their roles and resources as their desires. And each node behaves as autonomy in MANET. We also provide protocol components for managing node's resources and negotiating requested services from adjacent nodes, and including some detail about how these components work together. Performance evaluation and analysis will be done in the future works by using NS-2 [9] network simulator.

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