Resource Aware Application for Mobile Device In An Ad Hoc Wireless Network Environment

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***Abstract*—Ad hoc wireless networks can be applied in a collaborative computing in which the requirements of a temporary communication infrastructure for quick communication with minimal configuration between a group of people in a conference or gathering. The main purpose of this research is to develop an application that allows mobile nodes in a collaborative environment to share files among nodes. For this project, the application will be implemented on nodes in an ad hoc wireless network that have a strong incentive to collaborate and share resources. This paper presents the results of our preliminary study which are based on the previous research. It is divided into five sections where in the first section is an introduction of ad-hoc wireless network, then in the next section is regarding motivation of doing research in this area. In section four and five, the paragraphs focused on the evaluation for Mobile Ad Hoc Networking and related works respectively.**

***Keywords*—Component; Ad hoc Network, Collaborative Environment, Resource Aware**

I. INTRODUCTION

Traditional ways of sharing information and resources in a collaborative environment that involve centralizing data and services are not suitable for ad hoc wireless networks due to its dynamic nature since a centralized resource can become a failure point in a collaborative environment and jeopardize a collaborative process.

An example of a collaborative ad-hoc group is a group of participants in a conference room. Participants would want to exchange their papers or data using the wireless devices, which range from laptops to PDAs. So in order to enable them transferring file between devices they need to detect the other node in the ad-hoc network and then establish the connection by transferring a file to the other party. This is something like peer-to-peer file transfer in a collaborative ad-hoc environment.

This project aims to develop a middleware that is resource aware that can supports data dissemination in ad hoc wireless networks. Besides that this middleware should able to allow peer terminals authenticate among themselves. Basically the essential role of middleware is to manage the complexity and heterogeneity of distributed infrastructure and thereby provide a simpler programming environment. This paper is divided into five sections where in the first section is an introduction of ad-hoc wireless network, then in the next section is regarding motivation of doing research in this area. In section four and five the paragraph in focusing on the performance evaluation for Mobile Ad Hoc Networking and related works respectively.

II. AD HOC WIRELESS NETWORK

In general, wireless networking refers to the use of infrared or radio frequency signal to share information and resources between devices. It is basically divided into two categories namely, infrastructure-based network and infrastructure-less which also known as ad hoc network. Infrastructure-based wireless network is included fixed and wired network and access point and usually the data is delivered through preconfigured infrastructure [2], whereas wireless ad hoc networking which is also known as peer-to-peer network has no centralized access point. It is usually set up for temporary need such as during meeting or conference.

Ad hoc mode is a method for wireless devices to directly communicate with each other. Operating in ad-hoc mode allows all mobile devices within the transmission range connect to each other through automatic configuration. This not only allowing the nodes to communicate with each other, but also share the service such as Internet connection. To enable an ad hoc wireless network, the minimum requirements are two nodes such as PCs, equipped with wireless adapter that can set up an independent network whenever they are within the range of one another. The node is used as router and responsible to participate in the routing information distribution and maintenance, by running the same routing protocol [2].

The term Mobile Ad Hoc Networking (MANET) is referring to the technology that can support the operation of more adaptive wireless network. It usually consists of various end user devices such as laptop, PDAs and mobile phones. In this environment of networking the issues of CPU storage space, bandwidth and battery power represent the important resource [6]. Unlike the infrastructure-based network, the topology of MANET is commonly unpredictable and dynamically changed. MANET enables data transfer between mobile nodes via multihop wireless routes without depending on an infrastructure-based network. It can support autonomous and spontaneous networking and, thus, should be capable of self-organization and self–configuration [15].

III. MOTIVATION

In this section, we include the motivations and idea of coming up with the research on developing resource aware middleware for ad hoc network. This will cover the main research areas in MANET where the research works are still going on including middleware. Here, we give a special focus on developing middleware for ad hoc mobile environment and in order to do so, we list out some of the middleware issues and challenges for MANET. We will also discuss the existing methods of developing the middleware done by most researchers which has become a great issue that is using simulation or building real implementation

A. Middleware as One of MANET Research Areas

There are a lot of ongoing research works that cover a wide range of MANET issues [4] had come out with a reference that represents the research activities that has been organized in a systematic way as shown in Figure 1 below.

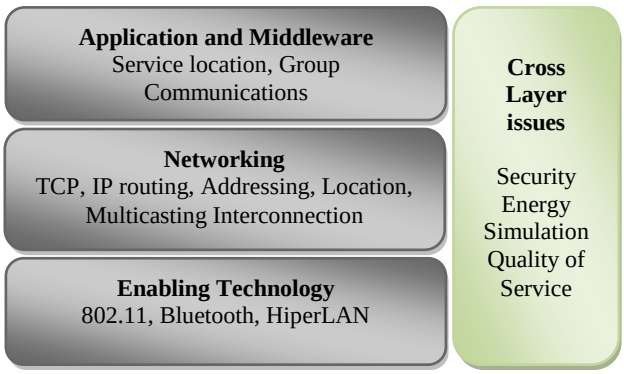

Figure 1. A Simplified MANET Architecture [4]

Figure 1 shows the different areas of MANET architecture where the research activities can be grouped into three main areas. They are organized in layered approach where the enabling technologies in the lower layer, networking area in transport and network layer protocols and finally applications and middleware area which are placed in the upper layers of the MANET architecture. There are also research issues covered in cross layer areas such as security, energy conservation and quality of service. As for this research paper, we focus on issues regarding middleware area.

Developing potentially useful applications for MANET is not an easy task for application developers as ensuring interaction among components on top of network operating system primitives would be too complex. Building new applications from scratch that is believed can solve various issues regarding MANET can be unfeasible. A possible solution to this is using middleware services that support development of MANET applications. The middleware service is able to offer information access and sharing, and considerable flexibility for MANET. The main aim of developing middleware is to enable communication and facilitate coordination in distributed system that will offer a much promising possibilities such as flexibility especially in ad hoc environment and also reducing complexity caused by the dynamic nature of mobility. By providing a higher level of abstraction, middleware makes distribution becomes transparent. This means the distributed system will appear as a single integrated computing facility in the eyes of the users.

B. Issues and Challenges of MANET Middleware

In general, there are different kinds of distributed system which can be traditional (fixed system), nomadic (a compromise of fixed and mobile system) or ad hoc mobile (completely mobile system). Therefore, developing middleware in different kinds of distributed systems mentioned above will create different issues and challenges as the concept of device, network connection and the execution context of each kind of system are totally different.

As for MANET, mobile applications run on limited battery powered device with low memory and slow processor. With these resource constraints, the coordination between computational load and the non-functional requirements in MANET should only be achieved by a lightweight middleware that provide effective use of processing, memory and communication resources, while maintaining low power consumption. Enable effective communication in MANET environment is not an easy task as well. In order to communicate with other devices either to exchange data or to request a service, mobile devices are only able to connect to the network in a very short period with limited network coverage. Thus, to allow effective interaction between devices that are not executing simultaneously, there is a need to establish an asynchronous form of communication [9]. By enabling asynchronous communication, a client might be able to request for a service at a certain time and without waiting for immediate response, the client is able to collect back the result at other time when he reconnects.

Another issue in developing MANET middleware is regarding heterogeneity. In an environment that has no fixed infrastructure where the network topology keep changing dynamically, building a reliable and yet a stable middleware is a great challenge to developers. With different components written using different programming languages, running on different operating systems, executed on different hardware platforms while facing various types of network systems, it is crucial to have a mechanism that is able to integrate these components so that communications in MANET run smoothly.

The execution context of a mobile system is extremely dynamic compared to fixed distributed system. By considering the unstable bandwidth, the unavailability of services together with limited resources in MANET, it is necessary to adapt context awareness technique in the middleware. Context here refers to every aspect that can impact the behavior of an application. The context awareness can be grouped into two types [7]. The first type is device awareness which relates to the internal resources of device for example: battery power, memory and processing power. The second type is environment awareness that relates to the external resources around the device such as the bandwidth and network connectivity. With context aware-middleware applied in the mobile system such as MANET, the information about execution context is passed up to the running application to let it take charge of strategic decisions.

There are many other issues and challenges that need to be considered as well in developing MANET middleware.

When the network becomes bigger where more nodes started to join the network, a middleware service should be able to handle the network flexibility and scalability by maintaining acceptable levels of performance. Allowing mobile nodes joining MANET network and communicate in a hostile environment will raise another issue which is much related to security: whether it is secure enough to allow unknown nodes join the network, what would be the possible protocols that ensure trustworthiness and at the same time maintaining the network performance. Handling security issues in MANET middleware need more research works depending on the requirement of the system as there are no standard security mechanism in MANET.

IV. Development and Performance Evaluation for MANET Middleware

Researchers have done a lot of research activities regarding mobile ad hoc networks. These include developing the MANET environment and evaluate the system performance either by building a model using simulation or running the experiment through real systems or test-beds. There are two main approaches in system performance evaluation. The first is based on a representation of the system behavior via a model and the second uses measurements [3]. Most results on the behavior of MANET protocols are usually obtained by defining a system model and solving it using simulative techniques. On the other hand, the second approach which uses measurements can be applied only when real system or its prototype is available.

Simulation techniques are commonly applied to evaluate the performance of MANET protocols when experimentation is not feasible. Most researchers choose to conduct simulation modeling as it is more standardized, mature and flexible to model various types of protocols and network scenarios. By setting the configuration of a network simulation package and varying certain parameters, simulation permits the study of system behavior of a model and allows analysis that can fully characterize the performance protocol. However, system developers need to ensure that the simulation is indeed reflects important aspects of reality so that it shows the real sight of the operating characteristics of the system. Using network simulation packages in conducting evaluation studies had raised some other issues. Most simulation packages are complex and they require huge computational load to execute. Typically, researchers tends to conduct MANET simulation using only one simulation package and they have sufficient experience and time for focusing on just one package [1]. Another issue raised regarding network simulation package is the contradictory of results of different packages. If each simulation package reflects reality, the results of all packages should agree but still in reality, the results are very much different between the simulators.

One probable solution in order to obtain more realistic performance results and to evaluate the actual inaccuracy of simulation's models is to complement the protocols evaluation via simulation by conducting experiments with real prototypes. Real prototypes or usually known as test-beds are experimental networks built and used for research purposes. There are a few numbers of institutions and universities built their own test-beds to evaluate performance of MANET systems as they are able to point out problems that were not detected by simulation studies. These test beds are ideally suited for protocol development and testing but are limited in capturing all of the significant behaviors. Even though constructing real test-beds for MANET are quite expensive and lack of flexibility probably in working scenarios and mobility models, it allows functional system drafts and analysis to be closely examined and increases the likelihood that invalid assumptions can be discovered [9].

V. Related Works

In this section, some of the research projects regarding MANET middleware that have been proposed are explained. These middleware have different approaches that covered some the most common issues in MANET such as service discovery, resource sharing and data transfer.

A. MARE

The MARE: Mobile Agent Runtime Environment is an architecture that facilitates the detection and manipulation of resources in mobile ad hoc environment. The aim of MARE is to move operations to the source of the operation with the help of agents instead of transmitting information across the network. Besides agent technology, MARE also exploits the use of tuple space that provides a communication medium within the system for transmitting resource information, messages and agents. Tuple space can be defined as multiset of tuples that can be accessed concurrently by several process where each tuple is a sequence of typed parameters and contains the actual information being communicated [11]. A resource can be deemed as any advertised service using an instance of MARE that could be interacted with such as video camera. If there is a case where more than one resource resides on any MARE instance, the resources can be advertised by bundling them together which eventually help in reducing the bandwidth and the number of separate network transmission. MARE is implemented in Java together with L2imbo platform for implementing decentralized tuple space that is specialized for mobile environments. MARE is said to be practical in an experimental application based on a scenario of mountain rescue. In this scenario, it is assumed that there is a team of rescuers and one of them may have limited equipments (resources). Each rescuer is able to create a collection agent on their PDA to collect information about available resources. The agent can be tuned with preference to use specific resources and it is also able to migrate to a host with available resources if the PDA power is down. The MARE research team also did a test scenario on resource discovery mechanism where the result shows that the number of messages passed between hosts using MARE while performing discovery of surrounding devices is much less than any other discovery mechanisms. This proved that the resource discovery mechanism in MARE is highly effective with efficient bandwidth.

B. PASIR

In a collaborative environment supported by stable wired and wireless networks, centralizing data and services are the most common strategy for sharing information. However, this strategy is not practical enough to be used in ad hoc environment where the network topology is highly dynamic and changes frequently. The signal instability, the tight bandwidth and the low availability of shared data space in Mobile Ad Hoc Network has become the main challenge in the design of groupware communication service. Thus, for a collaborative system runs well in MANET, it is essential to ensure high shared data availability. The Platform for Ad Hoc Sharing Information Resources (PASIR) is a service platform used to share information resources among members of MANET supported groupware session [12]. Built using C# programming language with its functionality provided by .NET framework, each and every components of PASIR is fully replicated to keep high availability of resources and services when they are shared by users through a distributed data space. The architecture of PASIR consists of three layers. Data communication and sharing layer is the lower layer that is in charge of providing network and data services among groupware application. The second layer is the coordination layer that allows user interaction with shared objects; be it flat files or COM objects such as MSWord, whilst keeping information about users, session and the shared resources. And finally the groupware application layer allows collaborative applications developed using PASIR services. Even though PASIR's major achievement is allowing the reuse of functionalities that keep an intact relationship with commercial frameworks and applications, there is still a limitation to it. This refers to the fact that its advantage can only be achieved by using the Ms Windows platform that explicitly lack of heterogeneity support.

C. LIME

LIME middleware aims at identifying a coordination layer that can be exploited successfully for designing applications that exhibit logical or physical mobility [12]. It adopts the communication model from Linda [13] that exploits the use of tuple space that acts as a repository of elementary data structures. LIME enhanced the model adopted in Linda by making it suitable for highly dynamic mobile environments. This is done by modifying Linda's tuple space by breaking it into many tuple spaces where each of it is associated to a mobile unit permanently. LIME also introduced the rules for transient sharing of the individual tuple every time when mobile host wants to establish connection with the other. A mobile unit is able to access the global context through an interface known as interface tuple space (ITS) that is permanently and exclusively attached it. Each ITS contains tuples that are willingly made available by each mobile unit and can be transiently shared among other ITSs belonged to mobile units within the community. There are two different kinds of operations that are performed in LIME. The engagement operation is performed upon arrival of new unit where the content perceived by each mobile through its ITS is merged. While the disengagement operation in the other hand, performed removal of data during departure of mobile unit. The main aspect in LIME lies on the ability of tuple access and movement along with notification to users when new tuple is available. LIME is currently developed as an open source project, which make it possible to be implemented on heterogeneity platforms. However, the lack of high mobility in LIME has become a limitation where mobile units can only be connected when they reside on the same host.

D. iClouds

IClouds is an architecture for spontaneous mobile user interaction, collaboration and transparent data exchange that is suitably adapt in mobile ad hoc environments [8]. ICloud or information cloud refers to the communication range of wireless device that exist in a form of a sphere around that node. When several devices join the information cloud, they are able to communicate and exchange information with each other. The iClouds communication horizon range does not exceed a few hundred meters. Hence, to allow easy collaboration within this range, multi-hop communication is ignored by excluding routing protocols. The main aim of iClouds is to make information of interest available to a groupware that shares common goal, based on individual contribution through peer-to-peer communications and data exchange. This can be done by enable sharing information contained in personally owned device called Minimal Entity (ME) or its associated Ubiquitous Associable Objects (US). Each of iClouds device contains two important data structures which are the iHave-list, a list that holds all information that user wants to contribute to iClouds and the iWish-list, a list that user specifies what kind of information he is interested in. A prototype of iClouds was developed using PersonalJava from Java2 Micro Edition (J2ME) that used the mentioned information lists through pull/push operation.

E. XMIDDLE

To address issues regarding the challenges of modern mobile environment, XMIDDLE is implemented by focusing on XML, a more powerful underlying structure and by supporting off-line data manipulation [10]. Using a tree like data structure, mobile hosts can establish efficient communication and for as long they are connected to each other, these mobile nodes are able to share and modify the information on each other's linked data trees. When they leave the network, the disconnected hosts will keep replicas of the trees they were sharing during online, and they can continue accessing and modifying it while off-line. When the hosts reconnect, the modified information will be brought together and patched up using the replicas of the previously stored tree. This will allow restoring of a small specific part of the tree rather than the whole tree which eventually make fast synchronization. However, this turns out to be a critical issue as not all devices has sufficient resources to update the whole tree at all times [13]. XMIDDLE also

features a protocol plug-in architecture, where a host can dynamically update its list of available protocols at runtime. The XMIDDLE platform is implemented in Java and relies on virtual machine. This has made XMIDDLE a platform independent middleware and supports heterogeneity.

TABLE I. SUMMARY OF RELATED WORKS IN MANET

Project Name	Description	Support Platform
MARE	Use agent technology to move operation to the source of operation Use tuple space Suitable for rescue scenario	Java and L2imbo
PASIR	Provide platform for resource information sharing	Windows
LIME	Exploit the use of tuple space which acts as repository of elementary data structure Support heterogeneity	Java
iClouds	Spontaneous mobile user interaction, collaboration and transparent data exchange	Java
XMIDDLE	Focus on XML technology Support offline data manipulation Device with insufficient resource will facing problem to use this middleware Support heterogeneity	Java

VI. DISCUSSION AND CONCLUSION

It clearly can be seen that, research area in MANET has several issue to be explored, such as in resource management, heterogeneous and security. Regarding to resource management, the problem can occur because of the device limitation as in MANET we will dealing with small devices such as PDAs and smart phones. These kinds of devices can only support small screen size, limited battery lifetime and memory size. In terms of heterogeneity, as in MANET, different operating systems and different hardware platforms for each node makes it difficult to develop an application that can be used by all nodes. This is because the devices may use different techniques to access to other peers in the network. The other issue with regard of security might be a problem when the number of nodes in the network increase, the system will need some security functions to control data dissemination among peers. The security element that might be useful is authorization, authentication and access permission. We hope with the proposed middleware, it can help in distributing data efficiently among peers in MANET.

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