Generic Service Provisioning Framework for Mobile Networks

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Abstract

Mobile ad hoc networking, as a typical example of self-organized networks, is an emerging and promising communication paradigm. Not only the variety of devices but also the diversity of services is continuously increasing. Such services must be provisioned in a flexible and distributed way without central infrastructure. Thus, service deployment and management for such mobile devices are extremely difficult since a provisioning framework must cope with the high level of device heterogeneity, degree of mobility, and take limited device resources into account.

In this paper, we propose SIRAMON, a generic, decentralized service provisioning framework for self-organized networks. SIRAMON integrates the functions required to deal with the full life-cycle of services. SIRAMON offers sufficient capabilities to specify, lookup, deploy, instantiate and manage not only trivial but also complex services like mobile ad hoc group applications.

1. INTRODUCTION

Ad hoc networks have been receiving much attention recently due to their immense field of application. A mobile ad hoc network is built of a collection of diverse wireless nodes (users). These nodes form a multi-hop network communicating spontaneously without relying on any pre-existing infrastructure or central administration. In order to make an ad hoc network functional, the nodes must organize themselves. They not only provide terminal but also relaying functionality for distant nodes. In this mobile ad hoc environment, efficient service provisioning requires flexible and distributed mechanisms. While the different applications and the great number of mobile devices make ad hoc networking interesting, the lack of central infrastructure, the high level of device heterogeneity, the degree of mobility and the resource constraints of devices make it hard to provide ad hoc services.

So far, applications of Mobile Ad hoc NETworks (MANETs) [1] have been envisioned mainly in the field of emergency and military situations. However, MANETs offer many more possibilities. We assume that mobile ad hoc services will be introduced in the future into everyday life, and not just supporting work or daily activities but also giving pleasure in spare time. Hence, complex Mobile Ad hoc Group (MAG) Services (such as distributed group games) will appear in MANETs soon.

While new applications in MANETs will provide powerful environments for group services, the complexity of service deployment and management in ad hoc networks calls for the support of a service provisioning framework. Traditional techniques for service provisioning used in communication and data networks (Jini [2], SLP [3], etc.) are not well suited for MANETs. First, they focus on a subset of service provisioning functionality (e.g., resource discovery) only. And second, they are often based on the client-server model using central infrastructure which is not available in mobile ad hoc networks.

2. SERVICE PROVISIONING IN AD HOC NETWORKS

Service provisioning in mobile ad hoc networks is faced special difficulties due to the constraints of MANETs – such as lack of central infrastructure, high level of device heterogeneity, degree of mobility, limited device and network resources. In this section, we survey these difficulties and identify the different service provisioning phases using a sample mobile ad hoc application scenario.

2.1 Sample Application Scenario

We use an imaginable scenario for an online multiplayer game in a mobile ad hoc network as our sample application scenario. A tourist, travelling by train, wants to spend his travel time playing a multiplayer game. To do so, he has a mobile device (e.g., a laptop) with a game software installed on it. Some other passengers on the train are supposed to possess also mobile devices that are able to communicate among each other and, at least, a couple of them are willing to play. While only some devices are capable to actively participate in the game, all may act as a relay to forward data. Since they have come close together, a mobile ad hoc network has been setup spontaneously.

Upon establishment of the ad hoc network, the initiator device advertises the availability of a new application/service on the network. When each of the connected devices is informed they can decide whether to join the game or not. Thereafter, the service will be automatically deployed on the selected devices (and in the network) and the game can be started. Further passengers are allowed to join (if the game allows for

late arrivals) and leave the ongoing group game at any time. Even the initiator must be able to leave without interrupting the game session for the remaining players.

2.2 Phases of Service Provisioning

Analyzing this sample application scenario we can identify the following phases of service provisioning.

In the first phase, the service to be provisioned has to be specified and named. We call this phase *Service Description*. The service specification must be able to describe the *role* of the node in the service, the *functions* of the service elements and the *connections* among them. For example, in our game service the specification has to describe the participating device's role (e.g., active player or auxiliary node which just aids the service to run), the device-level local view (the game is composed from moving pictures with music, sounds and voice requiring real-time interaction from the player, etc.), and the network-wide global view (the device has to communicate real time with all other player devices, etc.) of the game.

When the ad hoc network is established, the initiator device (the host) has to *advertise* the game service such that new participants can join. On the other hand, the devices of the other passengers must be able to *lookup* the service before deploying and using it. This phase is called *Service Indication*. Mobile networks have special constraints which must be addressed to develop appropriate service discovery mechanisms. Usually, MANETs cannot provide a permanent, central directory where the announced services can be registered and from where the available services can be read out. Moreover, the service hosting role can change dynamically in a mobile ad hoc group service.

When the devices in the ad hoc network are informed of the game service the next step is the *Service Deployment* phase when the game software has to be *requested*, *downloaded*, *installed*, *configured* and *activated*. This phase introduces some interesting problems. In general, heterogeneous devices form the mobile networks demanding support for several different platforms. Moreover, the lack of central infrastructure and the mobile behaviour of the devices make it impossible to discover network resources beforehand and to use them permanently during the service session.

After the game started the service *maintenance*, *reconfiguration* and *termination* functions come to the front. We call this phase *Service Management*. In the course of service maintenance the dynamic adaptation of the service to the resource variations must be assured. Service reconfiguration takes place fundamentally in two forms, locally and globally. We are talking about the former if a service user device modifies the configuration of its local service instance (e.g., selecting a better resolution for the pictures, etc.). In the latter the network-wide global view of the service session changes, for example, when a new player joins the game session. Local reconfiguration is mostly transparent for the other users while global reconfiguration is always perceptible for every participant. Service termination can be considered as a special reconfiguration if a service device stops running the service instance. This incurs also the release of the reserved resources. Moreover, dynamic adaptation to the resource variations and reconfiguration of the service session demand the continuous monitoring of the resources and the service context.

3. SIRAMON, OUR GENERIC SERVICE PROVISIONING FRAMEWORK

Our service provisioning framework is based on a decentralized and modular design.

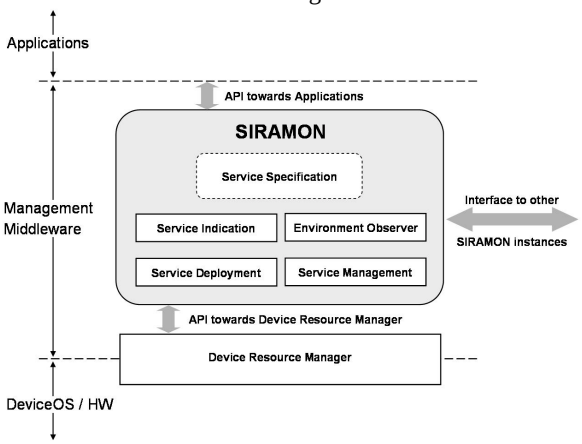

Fig. 1. Ad Hoc Device Model with SIRAMON

Every device runs an instance of SIRAMON which handles the control and synchronization among the devices, as well. We integrated the functions of the different service provisioning phases, as we discussed above, into separate modules.

In our device model (see Fig. 1), we introduced a management middleware layer where SIRAMON integrating the service provisioning functions is located. This layer provides an interface between the device's resources and the applications. The Device Resource Manager is responsible for controlling these resources and mapping them to service elements. Note that in this paper, we do not cover this latter module. In the following, we describe the different modules of SIRAMON.

3.1 Service Specification

It defines the service model used in the given service. SIRAMON is not bounded to any specific service model. The only requirement is that the service model must be able to describe the role of the node in the service, the functions of the service elements and the connections among them. In case of different type of services, it is reasonable to use different service models if the other model suits better for describing the given service. However, the service model must be carefully selected for the given service because it constitutes the basis of service provisioning and it is used in the course of the whole provisioning activity.

3.2 Service Indication

This module covers service advertisement and service lookup procedures. As we discussed earlier, due to the lack of central infrastructure, for service advertisement and lookup the traditional central directory model cannot be applied in ad hoc environments. A solution could be to replicate this directory on every device connected to the ad hoc network. Another solution is to establish a so-called virtual backbone in the ad hoc network selecting some devices which store a copy of the service directory.

3.3 Service Deployment

Deploying a service requires requesting, downloading software according to the specification; discovering, gathering resources; mapping of this specification to resources; configuring the resources and installing, configuring the downloaded software; activating the service in a synchronized manner along with the other service participants; and handing the control on to the management module. The Service Deployment module includes these functions.

3.4 Service Management

This module integrates the service maintenance, reconfiguration and termination functions.

Service maintenance is responsible for the dynamic adaptation of the service to the resource variations in order to optimize user's perceived service quality.

Service reconfiguration, as we discussed above, has two fundamental forms, local and global reconfiguration. The Service Management module gives support to global reconfiguration while local reconfiguration is in charge of the application.

Service termination can be considered as a special form of reconfiguration when a device stops running the service instance. All the other service participants have to be informed about the termination and the reserved resources have to be released.

3.5 Environment Observation

This module is responsible for monitoring the device resources and the service context. Resource and context information have to be gathered and transformed into an appropriate form, which can serve as input for the deployment and management modules.

4. RELATED WORK

Several proposals have been developed to standardize the functions of service advertisement and service/resource lookup (e.g., Sun's Jini [2], Service Location Protocol (SLP) [3] of IETF). However, these proposals are mainly based on the use of a central directory.

In contrast, some recently appeared new proposals directly target infrastructure-less networks. The Konark system [4] is a middleware designed specifically for service discovery and delivery of device independent services in ad hoc networks. Another proposal is the distributed service discovery architecture [5] which relies on a virtual backbone for locating and registering available services within a dynamic network topology. However, none of these proposals provide the full functionality of service provisioning.

5. CONCLUSIONS

In this paper, we identified the different phases of service provisioning in ad hoc networks and discussed the related difficulties. Based on this overview, we introduced SIRAMON, a new, generic service provisioning framework for self-organized networks. SIRAMON, with its decentralized, modular design suits well for ad hoc environments and it is flexible enough to cope even with complex services, such as mobile ad hoc group applications.

ACKNOWLEDGMENTS

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Biography

Károly Farkas, Lukas Ruf and Martin May have been working as research assistants in the Computer Engineering and Networks Laboratory headed by Prof. Bernhard Plattner at ETH Zurich. Their research interest covers the area of communication networks focusing on programmable, mobile and peer-to-peer networks. They are authors and co-authors of several journal and conference papers in relevant topics and active members of several international research committees.