A Multi-Party Approach to SLA Modeling
Application to WLANs

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Abstract—In this paper, we propose a service-driven model for structuring WLANs into overlay networks of interacting Wireless Management Communities. A Wireless Management Community (WMC) is composed of a set of Parties and is governed by a charter named the WMC-SLA (Service Level Agreement). A WMC constitutes the basic unit of management upon which will be installed any form of service interaction between parties belonging to the wireless community. The WMC-SLA model is presented as a use case of a more general SLA model we name GSLA. The GSLA is an SLA information model that supports multi-party service relationships through a role-based mechanism. It is intended to catch up not only the complex nature of service interactivity intra and inter WMCs but also the broader range of SLA modeling of all sorts of IT business relationships. This model accommodates both granularity and modularity of behavioral specifications by having each party playing a role within a service relationship. It intends to bring a step towards SLA-driven management within pervasive service environments.

Keywords: SLA; Wireless Networks; Multi-Party Services; Policy Based Management; Role based Management.

I. INTRODUCTION

The recent technological development in wireless and ad-hoc networks is fostering an enlarging spectrum of applications and services that ride upon such infrastructures. Today, the wireless users community is growing in an unprecedented way and will soon cover most first/last hop access networks. Wireless connectivity is accelerating the development of the main dimensions of nomadicity, embeddedness, and ubiquity [9] in the global internet. As such, the performance of wireless connectivity becomes of critical importance. It is no more a luxury but a requirement.

In this paper, we address the issue of wireless QoS or service level assurance support at the application and management layers. In order to enable service QoS support at both the wireless network scope and the end-to-end scope, we introduce a novel service management formalism that structures wireless networks into management zones or communities. Within such communities, service quality is governed through Service Level Agreements (SLAs) that are set up between Service Customers (SCs) and Service Providers (SPs) either implicitly or explicitly.

In another respect, SLAs are currently considered by both industry and academia as being of particular importance in service management of any sort independent of the type of communication media used to convey it whether it is wired or wireless. The GSLA information model we introduce has this spirit in its modeling and we show how it allows to model access to wireless communities as a service by itself upon which other services can be established.

After this brief introduction, the paper will introduce the concept of Wireless Management Community (WMC). It then explains the generalized SLA information model GSLA. After that, we would illustrate the multi-usage capabilities of the GSLA through the WMC-SLA. The paper concludes with an analysis of related and future work on the proposed framework.

II. THE CONCEPT OF A WIRELESS MANAGEMENT COMMUNITY (WMC)

We define a Wireless Management Community, or WMC, as a set of physically close wireless nodes that agree to gather for the sake of exchanging one or more services. The WMC is considered as the basic unit for managing a WLAN and is governed by a set of (either high-level or low-level) objectives and rules of behavior that are gathered within the WMC-SLA. The WMC-SLA represents the behavioral charter to which each member of the WMC is entitled to adhere to for the well conduct of communication services within the WMC. It is conceptually perceived as an SLA since having a WMC membership is viewed as a service by itself in the same way Network connectivity is considered a service upon which will yet ride other services such as Internet connectivity.

A WMC may relate to as many situations as is the diversity of our personal communication environments. It can relate to a corporate WLAN, a set of researchers or business associates holding a meeting, a teacher giving a lecture in a lecture-hall or at an open air field, a set of people doing some peer to peer file sharing, an open air interactive game, and even to some stringent situations such as military or disaster settings.

A WMC can have a void WMC-SLA and hence be completely open to any new member. This case can represent for example normal MANETS that offer best effort services. On the other hand, it can be strictly closed either in terms of its members or in terms of the membership constraints contained within its WMC-SLA. QoS enabled WMCs make part of this category of WMCs.

The intent we want to get from the introduction of the WMC concept is mainly to offer a structuring mechanism that would bring stronger service-level flexibility, security, reliability, and scalability to service interactions in a conglomerate of WLANs. These criteria are assured by the following properties we define for WMCs:
1. The first property concerns loose containment, which means that members of A WMC are not forbidden to belong to other WMCS unless explicitly stated in the WMC-SLA. This type of membership is not inclusive and is nearer to the notion of a directory or domain [4] with the added feature of having rules that govern the membership to the WMC instead of explicit afeckation.

2. The second property is that of scalable composition. By this, we mean that a WMC can also be defined in terms of a WMC-Expression representing a combination of union, intersection, difference, and complement operations applied to other WMCS. The difficulty here concerns the possible conflicts that might exist between the WMC-SLAs of the involved WMCS.

The environment that a WMC offers is by its very nature a multi-party environment in which each member has at least one active role to play. In the case of a MANET, the basic role which at least any WMC member must play concerns the correct routing of information within the WMC according to the WMC-SLA. WMC members are free to have other service relationships and interactions as long as they still respect the role assigned to them within the WMC-SLA.

The simple form of a GSLA occurs when two parties, say A and B, agree upon a given exchange of services. For example, A renders some service(s) to B and B renders another service(s) to A according to specified constraints. For instance, A and B can be neighbor Network Operators and the exchanged service concerns bandwidth trunks linking the two adjacent operator domains. In this case, it is both useful and more natural to catch up the service relationship between the two operators into one semantic and structural unit. The benefit is that the A→B SLA can contain any rule that relate to the service relationships between A and B leading to a more uniformity in the specification of contractual policies [1].

The most complex GSLA form we could encounter happens when more than two parties participate in the contract with more or less complex dependencies between all the involved services. This concerns for example situations where multiple service providers tightly cooperate in order to deliver strong e2e QoS assurances. Real cases of such a form of SLAs are found for example in MANETS, where all Ad Hoc nodes participate in the overall QoS aware routing policy. The GSLA we propose is enabled to cope with all of these complex cases.

In the following section, we develop the Generalized SLA model which serves a template for enabling WMC-SLAs and policy-driven QoS service assurances within a WMC. More detail about the GSLA model can be found at [2].

III. REQUIREMENTS FOR A GENERALIZED MULTI-PARTY SLA (GSLA) SPECIFICATION

Adapted from [16][12], an SLA is recognized to be a contract between a Service Provider (SP) and a Service Customer (SC) which is designed to create a clear measurable common understanding of the minimal expectations and obligations about what the customer is requesting and what the provider has committed to provide and at which constraints.

We believe however that this view of SLAs as concerning only single client-server relationships is restrained and is unable to catch up all real life situations where complex business relationships involving more than two parties take place and where SLAs are required to fix-up the rules for the well conduct of the business relationships.

This situation exists particularly in wireless environments where by nature many parties might be involved into a same service relationship, such as a video conference, a live scene multicast, a multi-player wireless game, and so on.

To differentiate the classic Client-Server view of an SLA that is predominant in the literature from the view we introduce here, we will call our Multi-Party SLA model the GSLA (for Generalized SLA).

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IV. THE GSLA INFORMATION MODEL

The study of a considerable number of real scale SLAs and SLA models [1][16][11][14] shows that all existing and proposed SLA templates have the same overall structural components. This sustains the idea of coming up with a unified information model for SLAs.

A GSLA is defined as a contract signed between two or more parties relating to a service relationship and that is designed to create a clear measurable common understanding of the role each party plays in the GSLA. A party role represents a set of rules which define the minimal service level expectations and service level obligations it has with other roles and at which constraints. The constraints might be of any type and normally include contract scope (temporal, geographical, etc.), the agreed upon billing policies, as well as the expected behavior in case of abnormal service operation.
Figure 3. (Summarized view of) The GSLA Information Model

We identify in Figure 3, the top-level components of the GSLA. A GSLA comprises a set of parties joined according to a certain schedule in order to realize the contract by playing each one or more roles. During the GSLA life cycle, a required behavior or constraint related to the GSLA is captured in the model by the abstract GSLAPolicy component. A GSLARole inherits indirectly from the GSLAPolicy. This is to catch the idea that a role is modeled at first approximation by a set of GSLA Rules, and as it participates in defining the behavior of the system, it is derived from the GSLAPolicy component. A Schedule component represents the temporal scope during which a GSLA component is valid. Finally, a GSLA object comprises one or more Service Packages to each of which is associated a Service Package Objective that some GSLA party is required to guarantee as is specified in its attached role(s).

A service package is an abstraction that enables different service elements (customer facing services) to be packaged together. Each Service Element is related to one or more Service Resources. A service element is enabled through a set of service resources. A service resource (SR) is intended to be transparent to the customer and represents a basic provider resource, such as an email server, a network element, a processing server, a database, a shared file, or a stockpile.

We propose a way for modeling QoS that caters for the specification of both high-level business objectives as well as that of low-level resource QoS parameters. Considering Figure 4., the Service Package Objective (SPO) component defines Service Level Objectives for one or more SPgs. Basically, an SPO is a constraint and we allow it to be defined in two possible ways: First, as a set of predicates or logical expressions over one or more SPg Parameters. This represents a high-level way of defining QoS objectives based on direct calculus made over high-level service parameters that are synthesized from basic System Metrics up through System Resource (SR) parameters and System Element (SE) Parameters. The other way around is to calculate the objectives based on QoS appreciations coming from subordinate Service Element Objectives. This represents the high-level compilation of low-level QoS appreciations. This latter approach reflects better the way users appreciate a given service infrastructure; i.e. by giving a final appreciation based on separate 'sub' appreciations over the different service components.

In the GSLA information model, multiple party service relationships are supported and each party has a set of SLOs to assure and some behavior to follow with respect to the other parties. Also, to each SLO are generally associated rules (or policies [1]) that define actions to take in case the SLO has not been respected or some threshold has been reached. We structure related SLOs and their corresponding policies into the Role class. Roles can be of several types: compulsory (such as supporting a specific routing scheme in an ad hoc WMC), optional (SuperNode in a p2p file sharing community), required by at least one party (Central Controller in an IBSS), or statically attached to a specific party (a VoD SP) at the GSLA specification time.

A party behavior is captured within the GSLARole component. As Roles are ultimately translated into low level policies [1], a party behavior at the lowest view is modeled as a policy. A policy is of two types, either a duty or an authorization. A duty defines conditions that need to be met in order to execute some system operations. They represent the key to QoS policy specification in our model [2]. A GSLARole is modeled through the set of duty and authorization policies having their subject domain the party (a VoD SP) at the GSLA specification time.

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After developing the GSLA model, we will now describe the WMC-SLA information model as a special case of it.

V. USING THE GSLA TO MODEL THE WMC-SLA

A Wireless Management Community SLA (WMC-SLA) exists within a WMC and contains all necessary information relevant to the profile of the WMC Parties and the basic services that exist, or are supported within the WMC. All types of WMC management policies also exist within the WMC-SLA; and we call Membership-Rules. They constitute a set of rules that are needed to manage events relevant to the WMC parties and the basic services offered by the WMC. Among these, we find authentication rules for new members and constraints limiting the maximum number of parties and the temporal interval within which the WMC is available.

Required Roles are also specified in the WMC. For example, a WMC for an ad hoc network might contain constraints concerning the ad hoc routing capabilities of the communication device used by each ad hoc party. Such constraints are collected within a compulsory role 'AdHocRouter' that each party should support. A new party cannot be accepted if it is unable to fulfill a compulsory role.

After the different roles and party profiles have been specified, there remains the issue of how users are actually connected to the WMC. This is a question that is closely related to the WMC-Controller. At least one party must play the WMC-Controller role. Because of the nature of WMCs, more than one party can play the WMC-Controller role; and depending on the WMC type, the decision process can be based on either one WMC-Controller or the set of all WMC-Controllers of the WMC.

VI. A CONFERENCE USE CASE

We consider here the case of a conference meeting in which a wireless infrastructure is installed to get access to the Internet and other networked facilities such as VoIP, p2p file sharing, Video Conferencing, local news Broadcasting, etc. In this regard, we would like to structure the different participants of the conference within a set of different but overlapping WMCs. The number of involved WMCs depends essentially on the importance of the conference and the number of participants. Major conference meetings, such as comsoc ICC or Globecom in the computing field, involve a considerable number of participants each of which may be involved in multiple activities during the conference lifetime.

In the context of the global Conference WMC, which we call "WMC-conf", each sub WMC has a specific associated WMC-SLA which subsumes (includes) the global WMC-SLA. In addition, association to a specific WMC may be based on an authentication mechanism and the WMC membership rules.

Figure 6. shows some intersection properties among all the possible WMCs that might exist within a conference meeting.

The WMC-conf takes care of continuously presenting to its members (or parties) the availability of the different sub-WMCs. When a user enters a technical session room, he would be invited to connect to that session WMC and start using available services.

Among the available services, we can find direct streaming of talks; questions/answers white boards; file sharing; live video chat, etc. Privileged in the talk streaming service are prioritized members such as VIP, the session chair/papers authors, but also those members who for some reason happen to be outside the session room but still want to get informed about what's happening around it.
In order to manage the services offered by the different WMCs, special QoS support needs to be provided by the wireless infrastructure; and a special platform is required to enforce prioritization policies and access control policies for the authentication of members; as well as special routing policies to manage the available bandwidth. Policies are required for the appropriate set up of talk(s) streaming or other videos, VoIP support, and the prioritization of traffic based on the importance of the conference members.

VII. Related Work

In the literature, several SLA information models are proposed. The main feature of those SLAs is that they focus on individual client/server relationships, with lower emphasis on the network wide view of services and SLAs interactions.

In the literature, two main works consider the network wide view of SLAs with particular emphasis on SLA parameter monitoring. WSLA [7][8] from IBM research and WSMN [6][11][14] from HP Labs analyze and define SLAs for Web Services by building new constructs over existing Web Services formalisms (WSDL, WSFL, XLANG or BTP/ebXML, etc.). It specifies SLOs within SLAs and relates each SLO to a set of Clauses. Clauses provide the exact details on the expected service performance. They are used to specify SLOs. Each clause represents an event-triggered function over a measured item which evaluates an SLO and triggers an action in the case the SLO has not been respected. In a recent work, [3] defines an FSA for SLA state management in which each state specifies the set of SLA clauses that are active. Transitions between states can be either an event generated by an SLA monitoring layer or an action taken by parties in the SLA. This represents a step towards the implementation of the declarative nature of SLOs.

[7] and [8] define the WSLA Language for the Specification and Monitoring of SLAs for Web Services. The framework provides differentiated levels of Web services to different customers on the basis of SLAs. In this work, an SLA is defined as a bilateral contract made up of two signatory parties, a Customer and a Provider. Supporting parties are sponsored by one of the two signatory parties to perform one or more roles. In this view, our model extends to multi-signatory-party service relationships with the supporting party role captured through delegation rules. WSLA defines an SLO as a commitment to maintain a particular state of the service in a given period. An action guarantee performs a particular activity if a given precondition is met. Action guarantees are used as a means to meet SLOs. In our model, we consider a modular design in which SLOs are first specified in a declarative manner. Then, special enforcement policies are generated to meet the SLOs. These policies need not be specified in contract sign time, they can change according to run-time circumstances. [3] considers a business goals oriented view, in which an SLO might be deliberately left down if it happens that this would help the responsible party maximize his local business objectives cost functions. Finally, [5] proposes a mapping of SLAs, defined using the WSLA framework onto the CIM Information model.

REFERENCES


VIII. Conclusion

In this paper, we considered the modeling of Service Level Agreements from the futurist vision of a network of interacting services governed by SLAs, which do take into consideration this high-level view within their intrinsic constructs. We developed the GSLA, a multi-party role-based information model for SLA specification, that is intended to catch up the complexity of future SLA-driven managed networks and systems. GSLA party behavior is captured into a unique semantic component; modeling a role that the party plays. SLOs are specified for each role and policies are used to enforce them. We illustrated the generality and applicability of our model through the concept of Wireless Management Community and the conference use case. Current effort is targeting the definition of a complete framework (architecture, language, and protocols) for the management of the GSLA life cycle as well as the development of a working solution for the WMC formalism. Finally, the applicability of the GSLA framework to other situations of IT business relationships which require more stringent QoS guarantees in GSLA contracts are also considered.