Activities of SDR Forum MLM Working Group on a Language for Advanced Communication Systems Applications

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ABSTRACT

The MLM Working Group in the SDR Forum has been working on developing a language which will allow mobile radio network elements to autonomously specify and configure networks by exchanging information such as: 1) Hardware capabilities of the nodes (Frequency bands, modulations, MAC protocols, access authorizations, etiquettes, bandwidths, interconnections etc.), 2) Networks available to a user (parameters, restrictions, costs), 3) Security / privacy (constraints, policies), 4) Information types (QoS, Priorities), 5) Local spectrum situation (spectrum activity, propagation properties), 6) Network to subscriber & subscriber to network control (policies), 7) Manufacturer matters (Hardware and software policy), 8) Types of users (Authority, Priority, etc.), 9) Types of data (Async., Isoc., narrow band, broad band, etc.), or 10) Local regulatory framework (e.g., policies at a given geo location, time of day, emergency situation, etc.). This paper describes the process that the Working Group is using, the current status of the work and the planned schedule going forward. A key element of the Working Group's effort is outreach and coordination with the broadest possible cross section of the industry.

1. INTRODUCTION

Over the last several years a series of papers, [1- 8], have been presented at the SDR Technical Conference on efforts to develop a comprehensive language that will allow radios and their associated communications systems to autonomously negotiate with each other to specify and configure networks in an optimal fashion given their capabilities, environment and the objectives of their users. This paper reports on recent progress being made within the MLM Working Group of the SDR Forum and plans to carry it forward. This paper is in some respects a shorter version of a paper[9] submitted to the DySPAN Conference, 2008.

The MLM Working Group is leading an effort to develop a formal language, with computer processable semantics, that could be used for describing all aspects of network operations and management. In particular, network components, e.g., wireless handsets, could use the language to describe their capabilities, which could then be used by the network to configure its own processing in a way that is a best fit to this particular handset/infrastructure. Similarly, wireless systems around network edges could negotiate with the infrastructure to achieve optimal solutions. This is becoming more critical with the adoption of Femtocellular architectures.

To this end, the standardization effort initiated at the MLM Working Group is tasked with at least the following two deliverables:

1. An integrated set of ontologies for the particular sub-domains.
2. A formal language, common to all the sub-domains, capable of expressing domain specific policies.

There are two dangers that must be avoided:

- Development of a Perfect Language that nobody wants to use (not Ada nor Esperanto)
- Development of a large number of non-compatible languages that each solve one piece of the problem

To avoid these dangers, the semantic mechanisms and the language (semantic mechanisms, protocols, etc.) must be developed and approved by the largest possible cross section of the communities of interest. The primary purpose of this paper is to provide information to this broad community about on going progress and to invite participation from individuals and groups not yet involved.

It is important to note, that although the long term objective is to be as broad in scope as possible, it may be prudent to start with a somewhat narrower scope and extend and expand the language over time. In any case, because of technology regulatory and other evolutionary processes, the language will have to include a mechanism for ongoing updating. This process must balance the need for responsiveness with the need to again reflect the broadest possible participation.

2. PROCESS REQUIREMENTS

The Process described in this paper is based on the following top-level requirements and constraints:

(1) The process should identify self-controlling feedback mechanisms that would drive the development of the deliverables towards quality, and ultimately to the approval of the proposed solutions by the largest cross section of the communities of interest. In order to provide actionable feedback, the process must include the development of a "complete" set of artifacts that can facilitate the assessment of the quality of the ontologies and the language.

(2) The development should consist of two phases, carried out in a bottom-up fashion. Phase I should focus on the development of ontologies and policies. Phase II should generalize the results of Phase I and lead to a proposal of a standard policy representation language.

(3)The deliverables should be developed in a collaborative fashion. Consequently, the process should include tools for supporting such collaboration.

In addition, the language and associated semantic reasoning mechanisms are expected to address the following areas: (1) Capabilities of the nodes, e.g., frequency bands, modulations, MAC protocols, access authorizations, etiquettes, bandwidths, and interconnections; (2) Networks available to a user, e.g., parameters, restrictions and costs; (3) Security and privacy; (4) Information types, e.g., an emergency call vs. a “how are you” message; (5) Local spectrum situation, including spectrum activity, propagation properties, etc.; (6) Network to subscriber & subscriber to network control; (7) Manufacturer matters (hardware and software policy); (8) Types of users, including authority, priority, etc.; (9) Types of data, including async., isoc., narrow band, broad band, etc.; (10) Local regulatory framework, e.g., policies at a given geo location, time of day, emergency situation, etc.; (11) Time of Day at both ends of session and important points in between; (12) Geographic Location.

To begin the development of a process for these requirements, a process framework needs to be selected first. In this work, we selected Rational Unified Process (RUP) as a guiding principle and as a way to represent a process. The main concept of RUP is outlined in Section 3.

3. OVERVIEW OF RATIONAL UNIFIED PROCESS (RUP)

A RUP process includes four phases: Inception, Elaboration, Construction and Transition. Each of the phases may include a number of iterations. Inception is about an understanding of what to build. Elaboration leads to the understanding how to build the artifact. Construction is the actual implementation of the software system. Transition is the deployment of the software to the user. Each of the phases may include a number of iterations. Inception is about an understanding of what to build. Elaboration leads to the understanding how to build the artifact. Construction is the actual implementation of the software system. Transition is the deployment of the software to the user.

The structure of a process includes: Roles, Artifacts and Activities. Views of the process are shown using various UML diagrams. The symbols are shown in Figure 1.

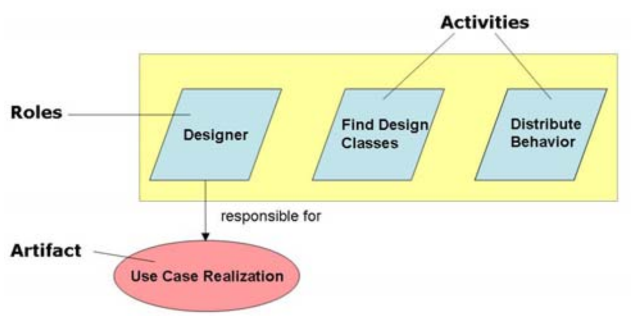

Figure 1: RUP Components

4. MLM PROCESS: ACTIVITIES AND ARTIFACTS

The following activities have been proposed for the MLM Process (not necessarily in sequential order):

1. Develop Use cases
2. Propose an MLM Architecture

3. Develop scenarios from use cases
4. Provide data for the scenarios (gather, simulate)
5. Develop ontologies for use cases
6. Develop policies needed for use cases
7. Select or develop inference engines for testbed
8. Simulate scenarios on testbed - test and evaluate
9. Select and/or specify, MLM language
10. Outreach occurs continuously during above process
11. Iterate and provide feedback based on results

To map the language development process into the four phases of the RUP, we begin by showing Table 1. The table includes all the activities and indicates of which activities are included in the particular phases. The fact that a given activity is part of a specific phase is indicated by the 'X' mark in the appropriate row and column.

	Activity	Inception	Elaboration	Construction	Transition
1	Use Cases	X		X	
2	MLM Architecture			X	
3	Scenarios	X		X	X
4	Data/simulation/testbed		X	X	X
5	Ontologies	X		X	X
6	Policies		X	X	X
7	Inference engines		X	X	
8	Test results/data		X	X	X
9	Language specification	X	X	X	
10	Outreach	X	X	X	X
11	Feedback	X	X	X	X

Table 1: Major Activities within each phase of the MLM process

Below we describe each of the activities. Since the artifacts produced by the MLM process are in roughly one to one relationship, we describe the artifacts and the activities together.

4.1. Use Cases and Scenarios

This section summarizes the use cases on actual or credible events relevant to public safety and commercial applications that have been considered so far within the SDRF. The use cases are constructed so as to focus on a particular aspect of an application of MLM in a tightly constrained space in order to simplify the construction of Sequence Diagrams and Ontologies. Ultimately, these use cases will be concatenated and extended to produce a global solution.

The use cases we have used so far in the process of language development include:

(1) **London Bombing Use Case.** Based on the terrorist event that happened on July 7, 2005 in London, this real-world scenario identifies the cognitive capabilities to: (a) provide network extension for coverage and reachback; (b) identify unused or underutilized spectrum when system was overloaded; (c) temporarily reconfigured with higher priorities based on the circumstances of the emergency responders; (d) allow non-first responders communications access to first responders in specific situations in which the non-first responders are actively participating in the response, while ensuring that mission critical public safety networks are not impacted.

(2) **Urban Fire Use Case**. In this scenario there is a fire at a chemical plant in an urban environment. There are three roles: an Incident Commander (Leader), a Fire Service Person and an Emergency Medical Technician (Medic). The leader's radio is able to: (a) determine which base station can provide the most reliable service for its needs; (b) register with the base station as a leader; (c) deduce what service each role needs; (d) determine the best available spectrum to use for each role; (e) instruct the fireman and the medic on what actions to take. The fireman and medic are able to (a) download different AIS in order to connect with the leader; (b) switch between different spectrum in order to download the required software; (c) set up VOIP and streaming video session with the leader.

(3) **Load Balancing Use Case**. In this scenario load balancing is required at congested locations where a major sports figure breaks a significant record at a sports stadium. Load balancing might also involve moving into unoccupied spectrum assigned to another primary user by the governing regulatory body.

(4) **Software Upload Use Case**. In this scenario, a user requests a service from the handset. If the requested service is within the handset's local capabilities, the service is initiated either in its current configuration or in a reconfigured form. Otherwise, the MLM Reasoner (MLMR) will ask the infrastructure or other handsets within the communications range if they can provide software for the requested service. If yes, the software is uploaded and the requested service is established.[1]

[1] While each use case is focused on a specific topic, it should be understood that multiple use cases can be combined. In particular, the Software Certification use case may be involved in each of the other use cases, and is particularly important to software upload or download.

(5) **Software Certification Use Case**. In this scenario, a software vendor (SW Vendor) submits a request to an Approved Certification Lab for new software. The Certification Lab invokes its certification process that includes two subprocesses – Simulate and Approve. The testing results of the simulation for various devices will be evaluated to determine which devices can be approved.

4.2. Architecture of MLM

Since the goal of the MLM effort is to develop either a language (or a language with a set of dialects) that would satisfy the needs of all of the participants in the mobile wireless value chain, the issue of the architecture needs to be addressed. For a DoD cognitive radio program, an architectural solution with two languages – one for endogenous reasoning and another for exogenous reasoning, as proposed in [10] is being proposed for the policy based control solution (cf.. [11]). In this architecture, there are two reasoners, one for generating requests for transmissions and proposing parameters of those transmissions, and a second for the verification of the requests with respect to the policies applicable at a particular time and location. Another architectural issue that must be dealt with is the integration of procedural and declarative systems in an efficient fashion. For example, procedural tools such as MONOPATI [12] are key components when partitioning mobile terminals into groups.

4.3. Ontologies

Ontology is defined as the formal representation of a set of concepts within a domain and the relationship between those concepts.[2] Ontological representation is the mechanism used to exchange assertions and queries in the MLM use cases. The Web Ontology Language OWL is the most likely candidate for the expression of an ontology. Each ontology will be a formal specification of the set of concepts and their interrelationships used to articulate a given domain. It is also likely that an editor such as Protégé will be employed to describe these concepts (classes) and their properties. The OWL/Protégé combination is a widely employed tool that can enhance the community's acceptance of the ontologies. The ontologies that are developed will be computer-understandable specifications of the conceptual vocabularies used to denote the knowledge objects of a given domain together with a description of their interrelationships. Such ontologies are critical for expressing the semantics of the domain and for ensuring that actors are communicating with the correct meanings of terms.

4.4. Policies and Policy Language

Agent communication is governed by policies that establish the conditions under which they can operate with each other. A policy will consist of a set of requirements or constraints, together with an enumeration of agent capabilities and preferences. Some policies are permissive in that they allow certain types of agent behavior, while other policies are prohibitive in that they forbid certain kinds of behavior.

The policies to be developed in support of the use cases should be representative of several communication domains, including all the cognitive capabilities identified in the use cases in Section 2.1.

A cardinal principle of the policies of interest in this project is that they must have the flexibility to enable them to operate in loosely coupled service environments. This implies a language capable of expressing a range of policies rather than “hard coded” policies. The language must be expressive enough to be able to represent the policies that are relevant, but at the same time the language should be simple enough so that the computer processing of the policies be tractable.

4.5. Inference Engine

In support of simulation and testing of the scenarios in a Testbed, this activity will involve the identification and evaluation of available inference engines that are commonly used with ontologies to extend their utility. There are many examples of these, including Racer, KAON2, cwm, F-OWL, Flora-2, BaseVISor, OWLIM, Pellet, and others. W3C has the Rule Interchange Format (RIF) under development to provide a uniform mechanism for sharing rules.

4.6. Test Data and Results

In order to assess the correctness of the implementation of the logic on a cognitive radio, test cases need to be developed. Towards this aim, it is necessary either to gather real data, and then test the system with the real data, or if this is not available, provide simulated data. The MML Work Group is considering various alternatives in this respect at this time.

While single scenarios play a very important role in the process of developing the logic for the behaviors of cognitive radios, a single scenario is never sufficient to obtain a satisfactory assurance that the functionality of the radio will satisfy some external requirements. Thus the Work Group is considering test coverage issues. These include issues of representative domains (the use cases) and

[2] Definition from wikipedia.

issues of extensibility and performance. There will be two major types of results to be evaluated: (1) performance of the interface with different reasoners, which is a test of the language's capability to work with any suitable reasoner (interoperability); (2) correctness of results, which is an evaluation of the ability of MLM to "correctly" represent aspects of interest.

4.7. Feedback

Feedback activity will be included in each of the phases described in Table 1, from Inception through Transition. SDRF will seek feedback from all interested parties, the actors identified in the description of this process. Towards this aim, working documents will be posted at the web site for the MLM Workgroup and feedback will be collected and incorporated into consecutive versions of the work products.

4.8. Outreach

Outreach is important in three phases of this project: (1) getting the best input from the broadest cross section of the whole industry value chain and market segments, which requires publication in a broad range of technical and business media.; (2) harmonizing the related standards efforts underway in a variety of standards organizations, which requires a continuing effort to discover, liaise with and coordinate activities of related standards groups, industry consortia and government funded initiatives; (3) having the resulting standard incorporated into and supported by key industry and governmental bodies. In the government area, outreach should encompass the ITU and National regulatory organizations. The intention here should be to have the projects results incorporated into appropriate government standards and regulations. In the industry area, efforts should focus on such broad based industry standards groups as 3GPP, OMA and others of a similar nature.

5. CONCLUSIONS

In this paper we provided a brief overview of the efforts of the MLM Work Group of the SDRF in collaboration with other partners towards the development of an ontology for mobile communications and of a language to express both the ontology and of the network control policies. This is work in progress. The main objective of this paper is to inform the community of these efforts and to solicit active participation.

6. ACKNOWLEDGEMENTS

The authors would like to acknowledge the following people who are making special efforts to actively participate in the work presented in this paper: Todd Martin and John Strassner.

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