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Modeling and Managing Collaborative Sessions for a Virtual Organization

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***Abstract*— We propose a system that allows users to engage in collaborative sessions through a variety of communication tools running simultaneously. In this paper we use description logic to model a broad range of features of a proposed session and we validate it before it is invoked, by checking for consistency with constraints arising from three main areas. We ensure (a) that it will not exceed the capacity of the network given the bandwidth consumed by sessions that are currently running, (b) that it does not violate any of the physical limitations of the resources to be invoked, and (c) that the participants possess the expertise required to contribute to the session.**

I. Introduction

With the growing accessibility of the Internet and the sophistication of the middleware tools, many people are working with remote collaborators under the notion of Virtual Organizations (VOs) [1]. A VO consists of a group of geographically distributed people, and resources that allow working coherently as a whole, for example to conduct scientific research, industrial design, or solve business problems.

A growing trend for communications companies is to propose service-oriented architectures for configuring communication tools [2], [3], [4], [5], [6], [7], [8], [9]. Configuration information is dealt with at the services layer, which provides an alternative to the usually closed, proprietary communication protocols that prevent different systems from interacting. Through service-oriented architecture, which has the advantages of being multi-platform and loosely-coupled, a variety of communication resources and tools can be accessed, incorporated and provided simultaneously.

Thus service-oriented archtitectures are approprite for supporting VOs. Typically each VO shares a pool of service-enabled resources and communication-enabled tools that may include software applications, hardware, data collections, computationally powerful computers, mass storage devices, and even specialized applications for configuring optical private networks [10] [11].

In this paper we present SAVOIR (Service-oriented Architecture for a Virtual Organization's Infrastructure and Resources), and emphasize the method of modeling high-, medium- and low-level aspects of the collaboration. The high-level includes the expertise and location of participants, the medium-level includes the capabilities of the communication devices, and the low-level includes the topology and bandwidth capacity of the network. With this broad model, we can adjust sessions to make best use of the personnel and resources available.

The paper is organized as follows: We present some related work in the area of communication technology based on web services and some previous work on which SAVOIR technology is based. We then discuss the design of SAVOIR and how it can be applied in a Health Services Virtual Organization (HSVO) setting. The next section describes how SAVOIR models high- medium- and low-level aspects of sessions, and illustrates the advantages. Finally we present our conclusions and tasks left for future work.

II. Related Work and Background

Previous work by a team at Avaya seeks to deliver voice and multimedia services through Web services, opening the usually proprietary systems to open standards [4], [3], [5], [6]. For example the services provided by the SIP protocol, which is based on neither XML nor Web Services, can also be provided by WIP, as described by this team.

Other work on unified communications and communication enabled applications is proposed by a consortium from Nortel, IBM and partners [2], [7], [2], [9], [8]. This team proposed to set up a sandbox for partner companies to trial new services, testing for interactions and compatibility.

These efforts illustrate that there is much interest in delivering suites of communication products that interact with the existing telephone systems, and apply the mature telecommunications architecture to the problems that will be encountered. In this paper we focus on just the high level modeling of the service suites, which is a technique that can be applied to all these efforts, but is somewhat orthogonal to the work on the protocols themselves.

Network Description Language(NDL) [12] is an RDF-based ontology that provides a common vocabulary to describe the topology of a network. This is particularly useful for provisioning systems such as optical networks, to exchange information at a domain's boundaries with other domains to extend paths. However, for upper level systems such as SAVOIR to determine whether or not a certain user request can be fulfilled by the network, the current NDL description is not sufficient. We need additional information about the routed network topology and VLAN information for a full description of the whole end-to-end network.

The Eucalyptus system [13], [14], [15], [16], [17], [18] provides industrial designers and architects with the tools to fundamentally change the process of design, by enhancing communication, application sharing, access to batch processing by supercomputers, network bandwidth file sharing, etc. Eucalyptus is specifically designed and built for architects and industrial designers. Architecture and industrial design are advanced professions requiring collaboration of a diverse team around powerful visualization and modeling tools. Our team is responsible for the web services infrastructure bringing the tools together. The tools include lag-free and jitter-free UltraGrid uncompressed high definition videoconferencing [19], delivered over a high speed research network using User Controlled Lightpath Provisioning (UCLP) [11], [20]. It also included desktop applications like Maya from AutoDesk and OpenSceneGraph for sharing access to high-fidelity 3D models of a city street-scape, replicating ten city blocks of Montreal's Boulevard St. Laurent. The architectural team reported that working with these tools greatly improved their ability to collaboratively design, share insights, and work productively.

III. Design of SAVOIR

Derived from Eucalyptus, SAVOIR is designed to be a generic service-oriented framework that can be used by different virtual organizations using different sets of resources. SAVOIR is a generic tool for combining any communication resources, possibly including legacy systems, that can be invoked through web services. The SAVOIR client interface appears as dashboard and acts as an integrated service client for accessing resources in a VO. The set of resources that appear on the dashboard is customizable. Each resource is represented as a widget that can be added or removed from the dashboard. Thus the user can choose what widgets will appear in the dashboard. The widgets allow her to control the resource, and to select or deselect it for use in a requested session. See Figure 1.

Specifically, given a WSDL file that describes how to access a resource or tool, and given a widget-based user-interface to allow end users to manipulate the resource, SAVOIR can incorporate the resource and the interface to manipulate the resource. In addition to providing access to the resources, SAVOIR manages the running sessions, which are composed of multiple simultaneous subsessions, each delivering a communication resource to specific users.

The core part of SAVOIR is a set of Edge Services and Platform Services. Each Edge Service manages a pool of resources of the same type, exposing the functionality of the resource to the users at session run time. It also manages the configuration of each of the resources. The Platform Services are web services that manage users, resources, sessions, and session workflows with the assistance of a set of utility services.

A. *Levels of Modeling in SAVOIR*

SAVOIR goes beyond Eucalyptus in modeling the middle-level of the usage of the resources. Eucalyptus provided

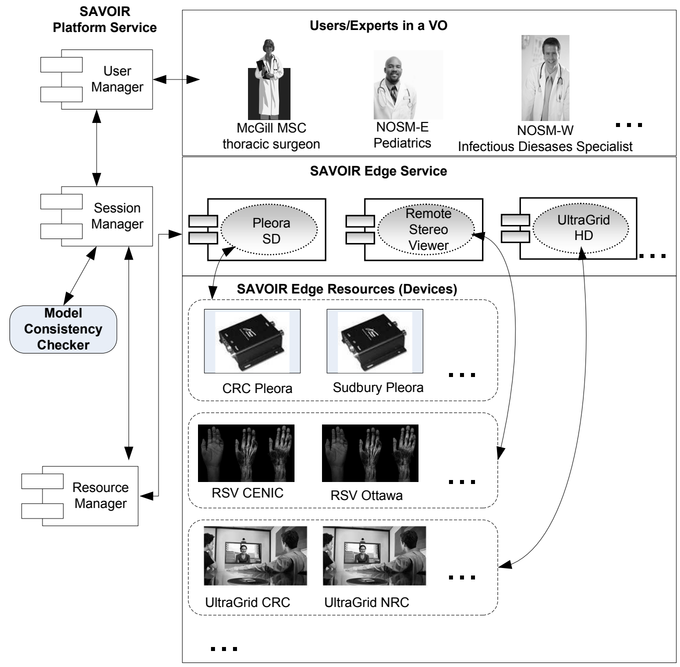

Fig. 1. SAVOIR overview

simultaneous connectivity with a variety of resources between a small set of users who could guarantee that all of the network and all of the resources were available. But in a shared environment, one cannot guarantee to have all of the resources available for one team. SAVOIR incorporates a modeling component that can determine what what resources are currently in use and can then determine what resources are still available. For a variety of reasons some additional resources may be run simultaneously and some cannot: network bandwidth, access permissions, physical limitations of the resources, availability of personnel with appropriate expertise, etc.

Typically a user requests that a session be invoked for communication among a set colleagues, and that a subsession for each of a set resources be started and managed by SAVOIR. An analysis must be done to determine that the resources can in fact be run simultaneously, and moreover that the session can be started without interfering with the other sessions that are currently running. This check involves several conditions. Do the participants have the necessary permissions? Are there any resources that can support only one connection to a user at a time, but more than one of these connections will be needed simultaneously to satisfy the new request?

It is necessary to include the high-level user expertise, and low-level network capacity in one model; if a user with the requested expertise is not available to assist because the network is too congested to allow the requested mode of communication, then either a different mode of communication or a different user must be found. (In future work we consider choosing a different time to hold the session.)

Just as a user can request resources for a session, she can also invite people to join the session. The members of the HSVO that are logged into SAVOIR are made visible on the

```
Session and hasSubsession some
   (Videoconference
    and hasUser some (hasExpertise value infectiousDiseases)
    and hasUser some (hasLocation value NRC_Fredericton)
    )
and hasSubsession some
   (RSVSubsession
    and hasUser some (hasExpertise value infectiousDiseases)
    and hasUser some (hasExpertise value thoracicSurgery)
    and hasUser some (hasExpertise value pediatrics)
   )
```

Fig. 2. SAVOIR session request

dashboard, along with their expertise and location. The user can also request that participants be selected based on their expertise, and not by name.

IV. Modeling Sessions: a Case Study

Consider the following example that we will use for the rest of the paper. A family physician in Fredericton, Canada requires the expertise of three specialists: a pediatrician, an infectious disease expert and a thoracic surgeon, to consult about a child in Fredericton complaining of internal chest pain and exhibiting a skin rash. The infectious disease specialist is in the Northern Ontario School of Medicine-West (NOSM-W) in Thunder Bay, Ontario, Canada. The thoracic surgeon is in MSC in Montreal, Canada and the pediatrician is in NOSM-E in Sudbury, Ontario, Canada. The consultation will require the Fredericton-based electronic health records to be shared with all of the consultants. The specialists will need to discuss pediatric anatomy over an RSV connection in collaboration mode using data files originating at CENIC (Corporation for Education Network Initiatives in California) and rendered in NRC Ottawa. Because RSV in collaboration mode requires a multicast connection, the Fredericton location will not be able to participate in that part of the session. To diagnose the skin rash, a high-definition point-to-point videoconference connection between Fredericton and the infectious disease expert is required. A standard-definition videoconference is also acceptable.

The Fredericton physician requests a session with the following conditions: (1) an RSV connection with three participants, an infectious disease expert, a thoracic surgeon and a pediatrician (2) an videoconference link with as high bandwidth as possible between himself with the patient and the infectious disease expert. SAVOIR converts this request to the class description, shown in Figure 2 written in a textual dialect of description logic.

Description logic reasoners always consider two types of information, the Tbox which contains general knowledge about the domain of interest, and the Abox that contains specific knowledge about the individuals in the domain. Most DL reasoners employ a tableau algorithm that reasons from the initial tableau consisting of the given Tbox and Abox, adding more facts that are deductively guaranteed by the rules of the tableau. Branching is done when there are choices of what new fact to add. Eventually either all branches are terminated with an inconsistency, meaning that no model exists, or some branch is created to which no new facts can be added. This branch is considered to be a model of the initial Tbox and Abox.

SAVOIR uses a custom-build reasoner based on this tableau algorithm to check that the description of requested session is consistent with general knowledge about the HSVO, in the Tbox, and the specific information about the network, resources and people currently available, in the Abox. For instance if it were known that no videoconference equipment could be used in Fredericton, then a request for such a videoconference session with a user in Fredericton would be considered inconsistent. Once the session request is shown to be consistent, we know that the model constructed on the complete branch contains information that can be used to construct a session according to the request. This model may not fill in all of the parts of the request uniquely and there may be several potential open branches. So there is still some work to be done before the session can be fully realized. Thus SAVOIR also includes a tool that adds specific choices to the parts of the model not fully specified by the tableau algorithm. It is written in Prolog and can backtrack though the different choices. Its result is a fully specified SAVOIR session that meets the description.

Figure 3 shows one potential fully described session it generates. In this figure, the object instances are shown usually in lower case (place names are the exceptions) followed by a colon and the class of the object. Its the attributes are beneath. Attribute names are indented once and are followed by the value of the attribute, itself an object:class, indented twice. Attributes of the same object are shown at the same level of indentation.

V. Discussion

In this paper we consider SAVOIR sessions, which use a service-oriented architecture to access resources that enable rich communications among participants in a virtual organization, often invoking several resources at once. We provide a model of a session that includes low-, medium- and high-level aspects of the virtual organization, representing at the high-level the people, their locations and expertise, at medium-level the resources, their capabilities and requirements, and at the low-level the network's underlying topology and bandwidth capacity. It is important to include all of these in one model to make best use of the resources and expertise. We illustrate how a model based on description logic can encompass almost all of the important considerations. Using a tableau reasoner, we check that the session requests are satisfiable with the rest of the environment. We extend the reasoner with a session composer that makes specific choices for those aspects of the session that are not fixed by the reasoner. We use a separate system to check the aggregate bandwidth requirements since description logic reasoners do not support arithmetic. If this bandwidth check indicates a problem, it is treated as any other inconsistent session, and triggers backtracking through the remaining choices.

```
session1 : Session
   hasSubsession
      video1 : UltragridSubsession
         hasParticipant
            drID : Participant
               hasExpertise
                  infectionDiseases : Expertise
               hasLocation
                  NOSM-W : Location
         hasParticipant
            drFP : Participant
               hasExpertise
                  familyPractice : Expertise
               hasLocation
                  NRC_Fredericton : Location
   hasSubsession
      rsv1 : RSVSubsession
         hasParticipant
            drID : Participant
               hasExpertise
                  infectionDiseases : Expertise
               hasLocation
                  NOSM-W : Location
         hasParticipant
            drTS : Participant
               hasExpertise
                  thoracicSurgery : Expertise
               hasLocation
                  MedicalSimulationCentre : Location
         hasParticipant
            drP : Participant
               hasExpertise
                  pediatrics : Expertise
               hasLocation
                  NOSM-E : Location
```

Fig. 3. Fully qualified SAVOIR Session

There are some weaknesses in the model as proposed that need to be addressed. In particular we have not tied the various subsessions together. For instance if one wanted the infectious disease specialist in the RSV session and in the videoconference session to be the same person, one would have to choose which person that is. It is not possible to express in session request that these two roles are filled by the same person while letting the system determine who that is.

Another future problem is to consider reserving equipment for sessions. If resources are able to be reserved for future sessions, then one needs to consider many other factors, including limits on the lengths of sessions, and search techniques for choosing a time when all participants, resources and network bandwidth are simultaneously available. Priorities for reservations should also be considered, and this is especially important for emergency sessions, prevalent in health care.

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