An autonomic open marketplace for service management and resilience

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***Abstract*—Expansion in telecommunications services, such as triple play and unified communications, introduces complexity that adversely affects service and network provisioning, especially in terms of provisioning times and the risk of delivery (failure) of new services. We envision a marketplace in which all manner of complex services will be provisioned, and their performance managed, especially against poor performance. The first phase of our work is a focus on the architecture, negotiation and management, which will lead to effective specification of network management requirements. We are working towards a bundled service agent architecture, which can negotiate on an open single service market, and which will eventually help to optimise the utilisation of the providers networks while reducing the risk of failure to users. Our work to date has been on the specification, behaviour, service definition and simulation of service agents for bundled service delivery.**

I. Introduction

The changing landscape of networking and distributed computing has introduced a vast array of new network services. Delivering these new services, such as mobile technologies, network based voice and video services and distributed cloud based computing services is often an arduous process, requiring considerable provisioning lead time and substantial risk. The improvement of network technology in recent years, however, has seen a reduction in the limitations to providing dynamic services, including greater available bandwidth, device configuration on demand, and a greater focus on service orientated networking. This capability has yet to be realised by an increase in the flexibility and performance of network service management systems.

II. Motivation

At the moment, the purchasing of single services places the risk and responsibility on the user. Failure of services requires manual intervention or renegotiation, with the accompanying time delay, being certainly undesirable. What is needed is a bundled service provider that manages multiple single service providers, for multiple services, accepting the risk for such services and guaranteeing delivery. We envision a marketplace in which all manner of complex services will be provisioned, and their performance managed.We are using bundled services as a representative complex service, which could be expanded in the future. Our previous work [1] has been around policy models, and we aim for the marketplace to work in concert with policy directed network resources.

Negotiation is seen as key to our marketplace approach, and, therefore a negotiating multiagent system is seen as the most likely implementation. It is clear that centralised approaches to network management are constrictive, due to the network being inherently distributed. An agent based system has a better chance of being able to scale because an agent system is inherently distributed and the agents are driven by goals, which are much more compressed, or condensed, compared with a policy approach.

III. Related Work

Policy based networking essentially allows the business rules of a company to become the authority for changing QoS requirements. A formalisation of this concept can be seen in Strassner's Policy Continuum [2]. The specification of the Policy based management has been implemented in a variety of Domain Specific languages such as Ponder [3] and PDL [4] and more recently languages based on ontologies [5] can provide some policy conflict resolution as well as some learning and reasoning capabilities. Autonomic computing and networking [6] with its deliberate biological connotations, describes a computing system's (or network system's) ability 'to manage themselves given high level objectives' [6]. All these types of management systems rely on the service definitions to provide the provisioning instructions for the network. Work has progressed in defining the provisioning goals of the network as Service Level Agreements between various service providers, users and billing agents and negotiated in an open market [7]–[11]. Research has gone into determining the most effective strategies for agent communication and negotiation of single services.

None of these systems consider the roles in terms of risk and responsibility. They also do not consider bundled network services, especially not on demand services. This does not mean that the systems are not adaptable, but the problem has not been considered by those researchers.

Various agent architectures have previously been put forward for service and network management, including [12]–[14]. All of these are designed for the network management layer, not the service management layer.

IV. DEVELOPMENT OF A SERVICE MODEL

A. Overall Model Description

We are working towards a bundled service agent architecture, which can negotiate on an open single service market, and which will eventually lead to optimisation of the utilisation of the providers networks, while reducing the risk of service failure. Figure 1 shows the overall architecture of the bundled services in an open marketplace.

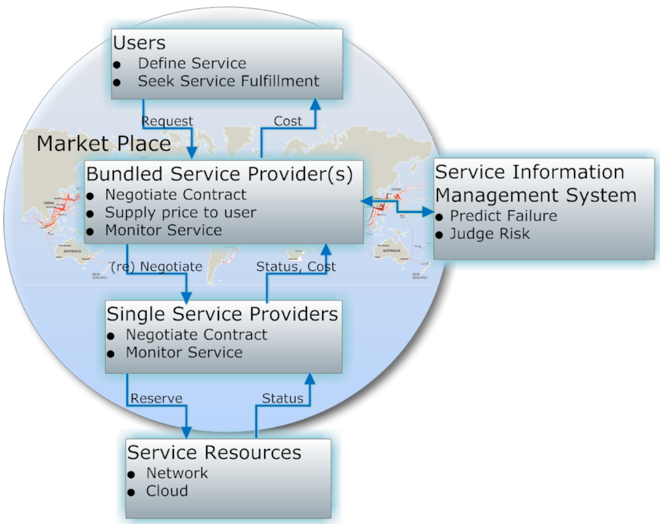

Fig. 1. The Architecture.

Users: make bundled requests via their user agents.
User Agent: (UA) negotiate with bundled service providers to obtain services at the required quality and price.
Bundled Service (BS): as described by the TeleManagement forum [15] is multiple services offered with incentives, that include extra organisational issues.
Bundled Service Provider (BSP): a service provider which provides bundled services to users, and negotiates with (a number of) single service providers to provide the user's service, at the required quality.
Bundled Service Agent (BSA): is a an agent assigned to a User request, and to the subsequent management of the bundled service.
Single Service (SS): The contracted SLA with a single service provider. Examples in [7].
Single Service Provider (SSP): is a provider of single services.
Single Service Agent (SSA): An agent in control of the single service for the selected service time period.
Single Resource(SR): a network resource. At this stage we are assuming a SR maps to an end to end MPLS path.
Single Resource Agent (SRA): An agent for a single resource. The agent keeps track of the resources allocated for the single services at the particular service times.

B. Service Information Management System

Bayesian Belief Networks [16] are the core of the SIMS. Figure 2 depicts the abstract, starting network (for all agents) which takes into account the BSA's position with respect to its current and future users as well as its currently contracted services and attempts to convert a set of variables carried by this context into one of the three decisions: do nothing, contract a new service and obtain a new user. The nodes (described below) fall into one of 3 groups: input, analysis and action.

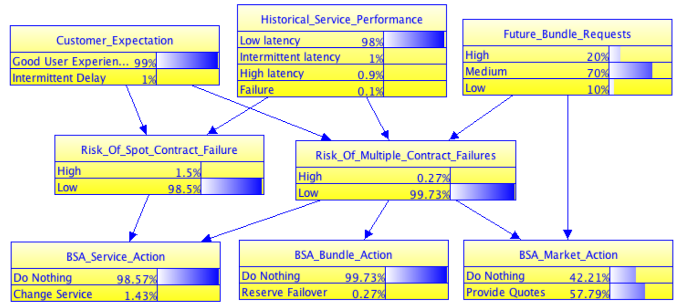

Fig. 2. Simplified Management BBN.

Customer Expectation: estimates of performance based on user information.
Historical Service Performance: aggregation of data from service's performance characteristics.
Future Bundle Requests: BSA's existing commitments.
Risk Of Spot Contract Failure: shows exposure to possible loss of income from a single contract which affects no other users.
Risk Of Multiple Contract Failure: shows exposure to loss revenue from a suite of contracts which may potentially result in a significant loss.
BSA Service Action: actions that affect one service within the bundle.
BSA Bundle Action: action that affects the composition of the bundle, in this case the BSA may decide to expand the composition of available resources.
BSA Market Action: represents BSA's behaviour in the market.

V. MODEL DESCRIPTION

The bundled service agent simulation is required to model: the processes of quoting, risk evaluation, single service negotiation (including re-negotiation on failure), and service completion and failure. Individually, the modelling requirements are: Process modelling, Constraints on state transition, and Goal based modelling, with explicit failure and abort states.

A state based model using Statecharts [17], was created to simulate the negotiation and provisioning of bundled services in an open market. The model follows the architecture described in Section IV-A and contains Bundled Service Provider agents (BSA), Single Service Provider agents (SSA), Service Resource agents (SR) and Users across a market environment. The model is a high level view of the system, focussing on the agents influence on service provisioning, and maintenance, specifically dealing with resilience and recovery.

A. Bundled Service Provider agents

The Bundled Service Agents (BSA) are responsible for negotiating utilisation of the single service providers, and managing the failure of single services in the bundle. The structure of the bundled service agent is based on the service definition provided by the user. Depending on the user's requirements in the service definition, individual modules to control the provisioning of each single service are added to the Bundled service agent, along with the for judging risk and negotiation/renegotiation. Figure 3 shows the control state

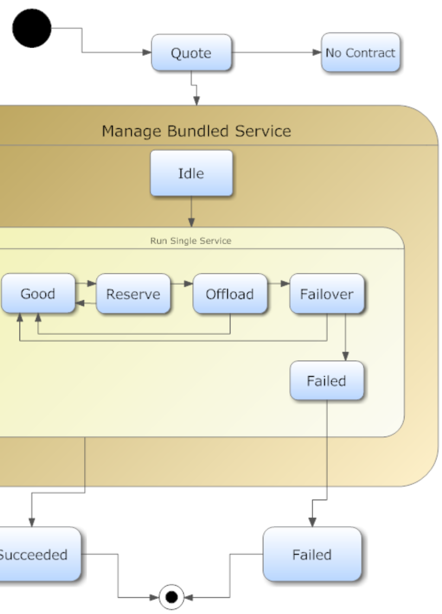

Fig. 3. The statechart control structure of the BSA.

chart of the bundled service agent for negotiation/quotation and provisioning of bundled services. The quote state provides the initial negotiation for all specified services, determining the constraints and judging the risk, using the BBN described in Section IV-B, for providing the service bundle with the chosen providers. The manage bundled service state starts the individual single service control statecharts with a start provider message. If all services are completed successfully the state moves to Succeeded, however if one single service fails and the BSA is unable to recover the whole bundle is considered Failed. The inner section of Figure 3 represents the control flow of the bundled service agent for interaction with the single service providers for a single service. The BSA sits in the run single service state, and waits for monitoring information of the SSA on the service resources performance. The monitoring information has been classified to four levels, green, yellow orange and red, indicating whether the service is fine, degrading, in danger of failing, or failing. The four states encapsulate the BSA's desire Run the service, Reserve resources on a secondary provider, offload on high intermittent failure and Failover to the new provider on failure.In order to manage failure from the bundled services point of view, the bundled service agent renegotiates and swaps providers upon the receipt of poor performance information from the single service providers. The BSA utilises the BBN to determine the probable risk of engaging a particular single service provider for service recovery. Then the BSA negotiates a new contract with the chosen SSA for the remaining time period.

B. Single Service Provider agents

We have modelled single service agents to simulate failure and send internal monitoring messages on the current services performance. This allows the model to simulate the basic functionality of re-provisioning failed services with another provider for the remainder of the contracted time.

Each SSA in the model has access to one Service Resource, and, is responsible for provisioning and scheduling the resource across the Service Resource. The SSA sets the price of access which is determined by the resource cost and its utilisation. Currently the SSA agents implements a congestion pricing strategy which increases the cost of the service during periods of high Resource utilisation. This strategy of congestion pricing encourages bundled service agents to utilise other service providers during periods of high demand, ensuring that the risk to the performance of the already provisioned services is minimised.

C. Single Service Network resource

The network is modelled as a collection of single service resources. For the moment the resource is modelled as an abstract MPLS network, divided into four tunnels. The tunnels are labelled, as High, Medium, Low, and Best Effort and have appropriate queues sizes, and delays relating to their individual priorities. A pool for resource units represents the percentage of utilisation in the network. Greater utilisation of the network resource results in poorer overall performance affecting lower quality services first.

VI. Simulation

We have used simulation to explore the complexity of dealing with interacting agents and resources, and to achieve the required performance criteria of resilience and scalability. The following scenario was used to test the systems response. The scenario is a progression of services, with a video conference occurring at nine in the morning, followed by some remote processing in a cloud environment, which starts half an hour into the video conference and finishes half an hour after. The results of this processing are then sent to the company headquarters in France, to be discussed in another conference call. The user specification for this request is displayed in Table I.

A. Best Fit Resource Consumption

Initially for Best Fit Resource Consumption five service agents were engaged with the same specification. This specification was taken from the previous scenario and run concurrently. The BSA's search for the most reliable provider, with the required resources, and reserve that service. This decision on reliability is derived from the BBN's assessment of the providers. With this scenario requiring the greatest available resources (currently set at 20%) for all services the absolute maximum number of BSA's attached in one service period should be five. Further due to the nature of the scenario, which contains overlapping services for each BSA, it is expected

TABLE I
USER TABLE FOR BEST FIT SCENARIO

Name	Type	Start Time	End Time	From	To	Quality	Resilience	Min Qual	Possible
A	VC	9:30	10:30	Australia	France	Low	Low	Low	Compulsory
B	RM	10:00	11:00	Australia	UK	Low	Low	Low	Compulsory
C	NC	11:00	11:10	Australia	France	Low	Low	Low	Compulsory
D	VC	12:00	1:00	Australia	France	Low	Low	Low	Compulsory

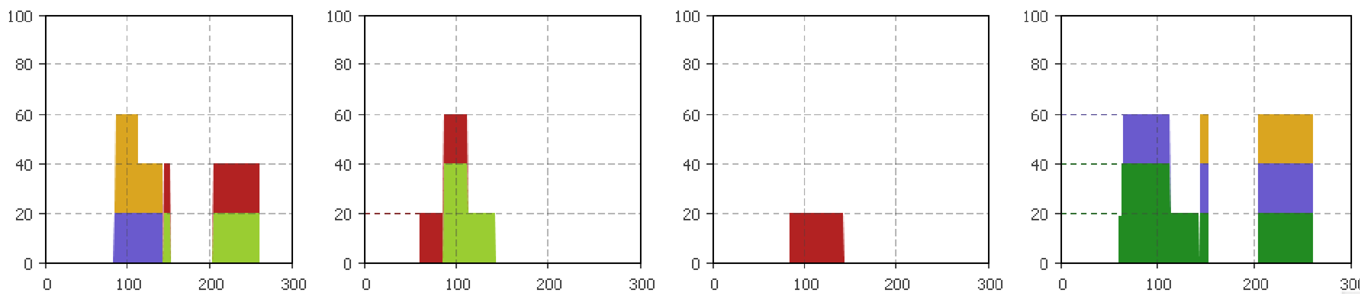

Fig. 4. The utilisation over time of 4 SSR's by a BSA.

to see that a minimum of two single service providers are engaged for the bundle.

Figure 4 shows the result of this simulation, The graphs show the individual percentage of utilisation of the BSA's on the five single service resources. the results shows that The BSA's utilise four SSP's to provide services rather than two, avoiding congestion on the individual services and reducing the risk to providing the bundles.

B. Scalability

To test the scalability of the architecture the same scenario was run with increasing number of agents and varying quality level requests. The simulation was run to judge the performance of the architecture in regulating the service resources under heavy and disparate usage.

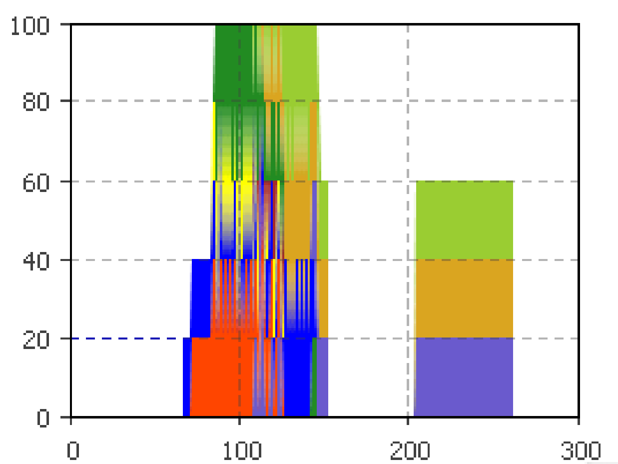

Fig. 5. The utilisation over time of one SSR by mulitple agents

Figure 5 shows the effect of 20 BSA's on one of the five resources, The graph shows that the greatest limiting factor is the resources themselves. The maximum number of BSA's that can operate at any one time will be a function of the availability of resources. The graph shows that the behaviour of the BSAs in this situation will be to continually switch between providers, looking for enough resources to fulfil the service. However, this continual switching is unlikely to be beneficial to the user and would result in service failure.

VII. CONCLUSION

This paper has presented the aims, architecture, concepts and ideas behind providing a bundled service agent for use on in open market. The foundation of the motivation for the bundled service agent is the wish to explore the requirements for cost effective and efficient network management, through increasing the utilisation of the service provider's networks. Further it is argued in this paper that dynamically created services are insufficient without the control provided by a bundled service agent that is prepared to accept the responsibility of the dynamically created services, performing the coordination of any composite service and guaranteeing their delivery.

Towards this goal the paper has presented: a descriptive architecture with components for negotiation, and, a method and approach to judge the risk of providing the bundled service.

To validate these ideas a model was created for the simulation of the bundled service agents behaviour. The simulation validated the behaviour and constraints on the bundled service agent's behaviour.

This work is seen as an important first step in matching the user's requirements, of resilience and economy, on dynamic network services.

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