Increasing Context Awareness in Autonomic Networks

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Introduction

It is now common knowledge that IP networks are increasingly becoming larger and more complex to monitor or fully manage in a cost-effective way. Network operations personnel have to gather information of diverse network components in order to manage the network and ensure advanced services such as security, QoS, user mobility and reliability for critical applications. This is a complex, error-prone and daunting task for humans.

Autonomic principles in data network management are introduced in order to address complexity of information and communication systems. In an autonomic environment, the network itself can detect, diagnose and repair failures and adapt its behaviour according to the network policies. The following self-* properties should be supported: self-configuration, self-optimisation, self-healing and self-protection.

Autonomic monitoring is a vital process in (autonomic) networks since it allows network components to assess their own state and the overall network conditions. However, predefining the monitoring scheme can be inefficient in heterogeneous environments, taking into consideration the constant changes in the network topology and the diversity of the interconnected systems. Therefore, the monitoring components within an autonomic network should be continuously adapted, in a flexible manner, to an ever changing network infrastructure (self-configuration). By increasing the context-awareness of monitoring data exchanged by autonomic nodes it is possible to efficiently sense network conditions and the level of provided services and proceed to corrective actions (self-healing). Also, context-aware information is easily used in order to take decisions according to the specified administrators' policies (self-optimization).

Context-awareness can contribute towards the reduction of complexity in the management of multiple mechanisms realised in autonomic networks. Sharing context-based information can be realised through dissemination of specific data among different nodes or through cross layer messages inside the same node. For example, a QoS entity responsible to allocate network resources exchanges context-aware information with other nodes in order to identify changes in the network conditions. This is a necessary capability of a QoS entity controlling a dynamic environment, especially in wireless networks where challenges are present due to user mobility and scarce network resources. Similar flexibility is needed in mobility management mechanisms where each node uses cross-layer information regarding availability of access networks in order to activate transport mechanisms.

Research projects recently proposed the use of context-aware information for improving monitoring mechanisms. FOCALE architecture [1] is based on dynamic control loops supplemented by the DEN-ng context information model at the node level. MOMENT [2] proposed an ontology for network monitoring tools but did not address any autonomic principles. In CONTEXT [3], the synergy obtained between context-awareness, ontologies and autonomic networking promotes the definition of a new, extensible, and scalable knowledge platform for the integration of context information and services support. Finally, in EMANICS [4] a new concept for context models is presented following the policy based management paradigm, suitable for representing information and managing services in cross-layered environments.

Context Awareness in Autonomic Networks

The incorporation of the autonomicity concept to communications systems makes necessary the development of extensible context models. These enable the efficient representation of available information, needed for handling and distributing it. Ontology engineering has been proposed as a formal mechanism for (i) reducing the complexity of managing the information needed in network management and autonomic systems and (ii) for increasing the portability of the services across homogeneous and heterogeneous networks. Learning and reasoning techniques have to be used to support intelligent interactions among the specified entities. Ontologies will function as core components for automated analysis of enterprise-wide event data, will be based on user-defined rules, trigger corrective actions for healing the system, deal with policy based goals on a higher abstraction level and provide new levels of functionality. These issues have to be studied in more depth as autonomic networks are coming into reality.

A generic monitoring framework based on autonomic principles has to be designed. It would be responsible for controlling monitoring protocols and mechanisms and enabling advanced node/network functions (such as QoS, mobility) to access context rich information necessary to realize complex control loops. Today, information and data models are not capable of representing the detailed semantics required to reason about behaviour. It is necessary to augment our use of knowledge extracted from information and data models with ontologies. Information about the current state has to be collected according to the information model and the use of a domain-specific ontology will add relationships between context data and the behaviours of the autonomic nodes, thus allowing them to reason about the modelled information and interact in a way that accurately reflects the overall network behaviour.

The proposed information model and ontology have to be extensible. Modifications and additions have to be done according to new interfaces that will be defined for interaction among the autonomic nodes, changes in the underlying autonomic network architecture, the definition of new elements and their relationships with already defined autonomic elements. Furthermore, they have to be unified and applied to the design and description of all the networking functionalities (such as QoS, mobility, routing, security). This will enable the use of common rules in the deployment of diverse scenarios. The model and ontology will be continuously updated in order to incorporate new associations among the autonomic elements and ensure that accurately reflect the current operational status.

References

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