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# Information Model for Dynamic Deployment of Services

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**ABSTRACT:** This paper focuses on the specification and modeling of concepts involving controlled and dynamic service deployment. This document provides an overview of our work in this context. We present our contributions; in particular, we describe an information model for representing network status and to facilitate the introduction of new services. Our information model, called Profiles Model, is centered in the notions of service and profile. Our model allows management of network resources to provide dynamic deployment.

**KEYWORDS**: Information model, Network Modeling, Dynamic Deployment, Networked service, Network.

## I.INTRODUCTION

The heterogeneity, dynamism and increasing complexity of current services and network infrastructures make difficult to operate and to manage new applications and services in a cooperative and flexible way. To meet this Challenge, different approaches have been studied over the past 15 years. Autonomous networks, overlay networks and most recently the network virtualization are some of them. These approaches aim finding solutions to automate the management, deployment and operation of the various elements involved in networked services.

The main idea of all these approaches is to automate the various management tasks, configuration, installation, deployment and supervision of services and networks. In this context, a dynamic deployment involves the network capability to ensure an automatic process to install the services requested by customers. This process implies knowledge of semantic services, network components involved and other resources. Thus, for a service deployment, it is necessary to make a configuration of each element involved in the deployment. This configuration requires the decision on which components should be selected based on knowledge of available resources of these.

Issues concerning the dynamic deployment have been dealt with two research contexts:

• Software component deployment for distributed applications. In this case, an application is view as a composition of software components, which must be put together. In this context the problem is How to make this composition? The semantic of service must be created and verified by the composition method. OMG and MDA approaches are involved with these aspects [1] [2].

• The dynamic deployment of networked services. In this case, we speak of networked environments, where different applications are running. The main problem is how to distribute the service requested and where it should be placed to ensure its correct functioning. TMF and DMTF [3] [4] are proposed of information model in this context. We are interested in the second aspect, but our model also considers the question of the composition of services.

The dynamic deployment of services and networks are one of the final objectives of current providers and operators. This dynamicity in the deployment requires absolute knowledge of the deployment environment, the network. To meet this need one of the problems is to determine optimal deployment strategies. This can be done through the analysis of the effectiveness of decision about placement of the service in the network, in terms of network resources and desired performance. This analysis can help assess the consequences of service deployment within the network based on the distribution of resources and obtain a service instance that meets the deployment contract. Automating the deployment tasks remains a continuous and evaluative challenge for telecom operators and service providers.

We are interested, in this paper, by the specification and the modeling of different notions treated in the context of networked service deployment. Despite the substantial work that has been carried in the area of network and service

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management, a common and general understanding of terminology has not been reached yet. One of the first notions defined is service. Currently the notion of service is treated in a different fashion depending on the concerned domain. In the context of future Internet the network modeling and specification are turned more and more toward a service-oriented perspective. In this paper, we present our point of view about the modeling aspects to be treated in the context of dynamic deployment of networked services. This document provides an overview of our contributions in this context. Section II presents an analysis about different approaches in the context of dynamic deployment. Section III presents a global view about our contributions in the context of information modeling to enable a dynamic deployment; and section IV presents our conclusions.

## II.RELATED WORK

The Internet has opened the way for new developments in the design, deployment and consumption of services. In this environment that becomes increasingly complex and heterogeneous, with users who have needs and uses constantly changing, and where the infrastructure must ensure access and execution services in a continuous fashion, deployment is the key step for suppliers / operator enabling to remain flexible in their offers. In the last 15 years several approaches have proposed its solutions to deal with the challenge of operate and manage new services in a dynamic fashion. We analyze these different approaches in this section.

### Autonomic networks

The autonomic network has been a hot topic of researches in the last 15 years. The notion of autonomic network refers to networks that have the capacity to be self-configured, and self-managed according to the perception of their environment evolution. Such a system requires a minimal administration, generally at the political level. To implement this configuration in an automatic way, it is necessary to have an absolute and permanent control of the network environment, in order to apply the functions necessary to make it dynamically adaptable. A survey about autonomic service deployment has been found in [5].

Several services architectures have been proposed in the context of autonomous networks, especially in the context of Web services. In these proposals, the level of service is the major component involved in the implementation of management and monitoring services in an automatic way [6]. The definition of the level of knowledge in the autonomous networks was another subject of study [7-9]. Representation of knowledge information and ontology has been treated in [10-11].Other researches work have proposed the representation of a knowledge plane, specifying a high level model to represent what the network is suppose to do, in order to provide services and advice to other elements of the network. Proposals are focused in the use of artificial intelligent (AI) tools and cognitive systems [7] and in the distribution of knowledge information [12-13].

As part of the deployment of network services the major challenge consists of two questions: How to provide a high-level view of the network that defines the goal? How to do the acquisition and automatic processing knowledge necessary? Several studies have tried to answer these questions, and most of them agree on the fact that network-level objectives must be defined for network designers, and must be used to control the behavior of applications running and to guarantee the objectives of the user.

Deployment in autonomic networks refers to automate the configuration of different elements. In general, intelligent agents and policy-based approaches are combined to provide a complete infrastructure capable of handling the definition of objectives and allocation of operations. Ontology is used to organize information and help structure its relationships. The dynamic deployment of networked services can be considered high-level goal. Each network component has to work and make decisions, by generating and manipulating information in order to allow a dynamically installation of new services.

### Overlay networks: providing virtual routing and services at edge nodes

The notion of service is the basic element for the development of new services and architectures. Future network architectures are based on the notion service. Overlay networks have proposed a useful option to enable both the construction and the evolution towards future service networks. New issues are dealt with the overlay approaches: how to specify/define a service? And how should be deployed it? An overlay provides elemental functions to build

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distributed applications by defined an application-level network in an autonomous and decentralized way.

An overlay network is built on top of one or more existing networks, by adding an additional layer of indirection and/or virtualization routing, and changing properties in one or more areas of underlying network. Overlay networks are used to deploy functionalities at edge nodes without changing physical networks. Each node of overlay network must maintain a set of pointers to each of their neighbor nodes. In addition each component of overlay networks must maintain information about their context and their neighbors' one.

Deployment of a final service (end-to-end service) may be viewed as a set of installations and/or deployments of service components. The set of components must establish/maintain relationships. The addition of components gives the expected end-service. The set of components constitutes itself a service network. Thus, the provision of end-service can be viewed through the definition of overlay network, which represents the set of components and their relationships. The topologies of overlay service networks should be conformed according to the composition of the final service and depending on which components are deployed. The overlay network is superposed over physical networks and it can change in accordance with the constraints and preferences to validate the requested service. Thus, knowledge on network environment is needed, and each node of physical network can be able to take decisions about which component is used to give a service, and how this utilization affects the context of execution of the final service.

The overlay networks form a layer for the organization and communication of distributed applications. Several efforts have been made to support the deployment of overlay networks [14-16], and to propose architectures to support overlay services at application layer [17-19]. Examples of overlay-based architecture are proposed in [20-21]. Concerning the overlay frameworks and middleware implementations some examples are: Macedon, overlays, JXTA [22-25]. Other efforts in the field of computers, automatic and especially IBM projects have proposed infrastructure to manage and share resources dynamically and automatically; and to support different customer service levels [26-27]. Abstraction and specification of overlay networks is another important question to be treated. QoS aspects are introduced by [28].Specification language is described in [21].

Thus, in overlay approach the major preoccupation is the building of virtual routing aspect to put in relationship the services in overlay nodes. The deployment process consists in this context in the discovery, selection and activation of network nodes to treat with the flow requirements. The logic of the service is built at overlay layer, and the deployment strategies must enable to map this logic in a physical infrastructure. The composition of service is view at high level and builds over the communication infrastructure by using their network services. The major application in overlay networks has been the peer-to-peer approach. Peer-to-peer is an overlay network enabling the distribution of deployment applications such as content distribution, and application-level multicast services. Examples of overlay networks in the context of peer-to-peer are P-Grid, Pastry, ODRI, or Gia. [29] Proposes an overview about peer-to-peer overlay networks.

**Network Virtualization: towards programming and virtualization of network services**

Future networks are based in the convergence of service and communication infrastructures that will be replacing the current Internet. This approach involves providing new services, capabilities and facilities based on news approaches and not by using only the current networks technologies. Two major contexts characterize the challenges in the future networks: service-aware and network virtualization.

Virtualization enables to introduce dynamicity in the treatment of multiple requests inside the same physical infrastructure. That is the case of future Internet where different solutions must coexist. At network level the introduction of virtual networks can enable the deployment of new protocols and architectures in an independently fashion. The notion of virtualization and its utilization at network level enables to exceed the limits imposed by the vertical architectural services. Operators can thus offer more suitable and dynamically networks without having to

touch their physical infrastructure. Overlay networks was a first response to build the service at application level, virtualization is a new vision that can be applied at network level.

Virtualization of networks enables the dynamicity in both: in the deployment and utilization of network resources and in the adaptation to provide the flexibility of solutions proposed. Future networks will be designed by virtualization its

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devices and decoupling the functionalities at different planes: data, control and management planes. In the currently context of convergence between virtualization, service and networks, the programmability of the network is a key aspect. The emergence of network virtualization has gradually changed the network architecture. In the context of Cloud in particular, SDN (Software Defined Network) [30] and NFV (Network Function Virtualization) [31] two recent approaches are based on virtualization and programmability to the network. These paradigms provide today a more network abstraction by virtualization its services and programming its devices. SDN allows introduce programmability of the data plane by separating the control plane. The Open Flow protocol [32] and Flow Visor [33] are two major representatives in the context of SDN. Further study on all SDN controllers was carried out in [34]. NFV introduces the virtualization of network functions and the support of IT services. Thus, some functions such as virtualization routing function [35], and session border controller have been studied [36]. Other Network functions still remain open questions.

Virtualization imposes the new constraints at network architecture design. Research and experimental projects, such as GENI [37], 4WARD [38], Planet Lab [18] are proposed experimental platforms to test different types of networks (wireless, sensor, cellular networks, etc.). These projects use the virtualization and programmability technologies to create virtual networks over multiple network technologies. [39] Presents a complete survey about network virtualization. Most of the mentioned approaches define a virtual network from only an equipment virtualization viewpoint. But with network virtualization an additional level must be considered to define the logic of the virtual solution and its deployment. The deployment of virtual networks is a key point in the life cycle of services. The deployment of virtual networks must consider both the logical aspects of the programming of virtual nodes and constraints involved in their placement in a physical infrastructure. Thus, concerning the dynamic deployment of virtual network, a key challenge faced by network providers is how to offer an adequate virtual network and its suitable control plane while meeting QoS requirements of the flows transferred over it. Thus, automation of deployment, monitoring and management process is required to make networks dynamic.

All recent approaches present a futurist view about what a network could be? And how to design/deploy it?. Today the design and deployment of networks integrate a service-oriented point of view. With NFV this aspect is taken into account, programmability and design of virtual network services is feasible. Network services are view like a set of functionalities that are now virtualized and that comes to customize the network nodes behavior according with the flow requirements. The network becomes a platform that can be program by the third suppliers. Providers and operators are decoupled in their roles, and they can provider each of one their own services. The network offers becomes customizable and flexible.

**Network management information models**

Network management has been a hot topic of research in the last decades [1-2]. In this context, several "network aspects" can be automated: equipments configuration, service deployment, QoS management, etc. To automate and reduce the management complexity, it is essential to model the networks by describing the various components implied and their interdependences. Management network modeling constitutes the first step to represent the knowledge level about network environments.

Traditional approaches in network management have focused on developing protocols, such as the simple network management (SNMP) and data models, such as Management Information Base (MIB), with the goal to collect and report monitoring information to human operators, which must performing the service and component configuration and management tasks. The main limitation of these approaches was the overhead taking for the management system to treat any new consideration, because the changes in the system are treated manually. Autonomic approaches introduce the active network, policy based-management and agent technologies. These technologies enable to automate the deployment of different management strategies for performing the necessary management operations, but humanoperators are still really present concerning by example for the description and programming of the desired behavior in the system, the policies. They do not offer a real dynamic solution for the readjustment of management and configuration strategies. [40] Presents an overview about different technologies in network management.

DMTF, OGF and OASIS are three major agents in the context of standardization in management tasks in distributed

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environments. Important efforts in this area have been made by DMTF, TMF, IETF and 3GPP in the last 20 years. These groups propose different models (CIM, SID and MIB) to represent management elements in different domains (applications, networks, devices, etc). DMTF CIM [3] and the TMF SID [4] are the two industry examples of comprehensive information models that address network and non-network entities. CIM is an information model proposes by DMTF to describe the management information in the context of distributed computing. Management information for systems, networks, applications and services are described by CIM. CIM is described by using an object-oriented approach and defines the CIM Core and CIM Schema. CIM Schema consists in a set of information model to drive management task and apply at different domains: systems, networks, applications, etc. TMF has proposed SID framework. SID is modeling by using an object-oriented approach with UML. SID is proposed like an Information Framework, which focuses in business entity and the description information and data in a business-oriented perspective.

In most recently Cloud environments several effort on information model to management Cloud services have been made. One of major effort in the information model of Cloud resources is proposed in CIMI (Cloud Infrastructure Management Interface) model [42]. The most recent proposition shows the use of CIM representations to enable CIMI resources to be management in cloud environments. The CIM model is also using by current OVF language to describe hardware resources in Cloud environments. OVF (Open Virtual Machine) is a specification defining a portable-neutral format package for virtual machines [43]. OVF propose a first solution to consider the description of virtual machines to be deployed. [44] Presents an overview about Cloud standardization initiatives.

CIM and MIB are two used structure models enabling to describe the current network load, latency and other parameters. They are used to describe different network components and their performance metrics, but the issues concerning the dynamic deployment of these components are not treated. Concerning the autonomic approaches the only standardized model for network control-knowledge is the IETF PCIM (Policy Control Information Model) [45]. OVF is a most recently approach enables to describe virtual machines to be deployed in Cloud environments.

All the proposed models have presented only an equipment point of view about the information to be considered and described. Considerations about a service-oriented perspective to a dynamic deployment of services and networks are still open issues. Standard API is still a lack to be considered in the deployment of future services and networks.

## III.INFORMATION MODELING PROPOSALS

### Profile model description

The concept of dynamicity implies all the characteristics of adaptability and configuration of the services to take into account the changes of their context of execution. The dynamicity can also be seen as being all the networks mechanisms, which allow the deployment, the monitoring, and the upgrade of the services. This concept implies: (1), knowledge of the properties of the execution environment: resources and services available in each network node and

(2) the mechanisms necessary to create, compose and deploy dynamically services. Different tasks must be performed in order to deploy a service: Service Discovery, Resource Monitoring, Node Selection, Resource Allocation, Code download & Deployment. We have situated our information model in the center of all these tasks.

We have proposed in [46-47] an object-oriented model to represent the different notions in dynamic deployment.Our information model called Profiles Model permits us to characterize the whole network and its hardware and software components. Two important notions of Service and Profile are the central points in our model. Profiles Model allows us to represent two points of view: the first is the current state of the network environment (that is the existing services and resources consumed or available), and the second is the necessary information needed for the installation of new services or the new profiles for already existing ones.

The notion of service is the point of view in our model such as a functionality that can be deployed. The general description of a service involves several aspects: the semantic of this service itself; the requirements about nodes/resources capabilities, eventually, the cost of instantiation/activation of this service and the other characteristics such as QoS (characterizing the behavior requested by the customer).Our model is articulated around the concepts of service profile, equipment profile and deployment profile in order to take into account all of the resources available and

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their evolution at the time of the activation of distributed services. Generally, a profile characterizes an entity (Hardware or Software) by specifying a precise configuration. In our proposal, we apply this concept of profile to define:

- Configuration of a material entity (equipment) with respect to the consumed/available resources (what corresponds to the equipment profile);
- Particular configuration for the execution of a service with respect to the constraints and needs for this correct functionality (what corresponds to the service profile);
- Precise configuration required by a user to deploy a new service (what corresponds to the deployment profile).

**Profiles model in autonomic networks**

Profiles Model is based on the major notions defined in the last section. These notions enable us to represent the knowledge of the service's execution environment. The knowledge refers to information describing: the service's requests, service definitions and service deployments. Three major packages are defined to represent it. These packages permit us to define the lifecycle of services and to organize the classes by according the phases of deployment of services (fig.1). Service Profile defines a type of service and associated the instantiation of necessary resources that enables us to describe a particular configuration for the execution of a service. Equipment Profile represents the configuration of an equipment entity (hardware, software or mixed components) allowing support the execution of the service. The Deployment Profile describes the service deployment requests in terms of resources and services required.

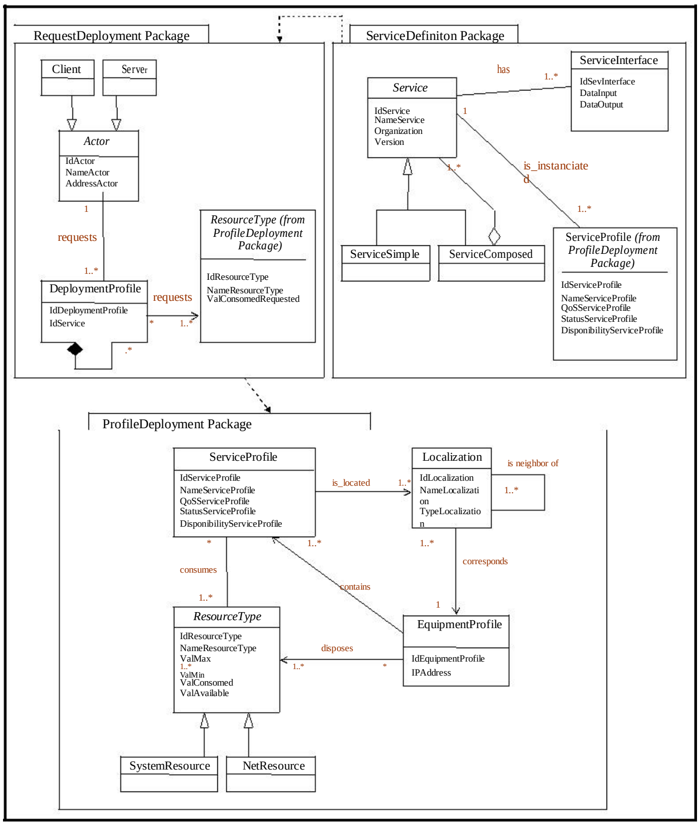


Figure 1: Profiles Model description

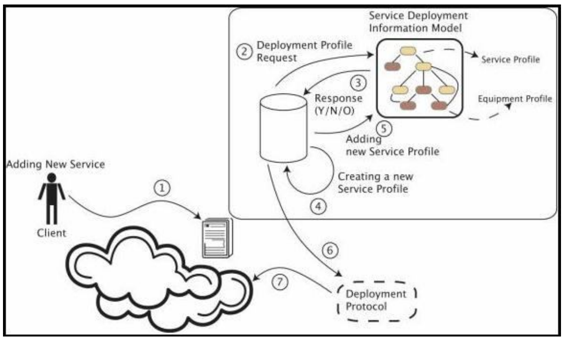


Figure 2: Deployment process with Profiles Model

We have proposed in [46] a first version of our model. This version is based in some assumptions:

• We consider a centralized management of the network. Thus, central network equipment is charged to store the current configuration of the network in the form of a database representing our information model. The instantiation of this database can be done manually (network manager), or through the use of a service discovery mechanism.

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Moreover, all change in the configuration of the network (i.e. introduction of a new service, etc.) must be initially submitted to the network manager.

• We consider knowledge on the relations between a composed service and the single services. Our model makes it possible to describe the relations of services composition.

• We consider the existence of the deployment protocols. In other word, we suppose the existence in the network of some mechanisms able to push some code within network nodes.

Service deployment with Profiles Model considers different steps (fig. 2). The first step to deployment is the request for service sent by user. This request represents the entry into our system and is represented by the Deployment Profile Request. The deployment profile enables us to verify the resources needed by the service request, and give a positive response (in the case where the system can find one or more nodes that satisfies this request) or a negative one (in the other cases). If the system can satisfy the service request, a new service profile is created, and this information is added to the system. At this time the system can update the information about available resources in the equipment profile, and the installation of services is then run by the deployment protocol.

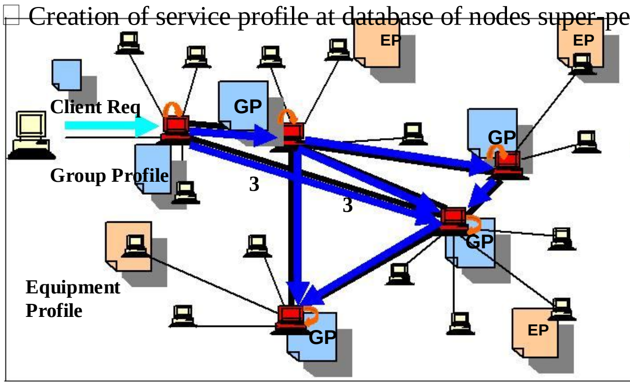
**Profile model in overlay environments: a peer-to-peer proposition**

Next generation networks comprise heterogeneous access networks and a high mobility of users and terminals. Overlay network has represented a first support to provide the mechanisms needed to guarantee different requirements: access, mobility, management and service definition. Overlay networks enable to define and implement abstraction solutions over physical infrastructures. New services and their deployment could thus be considered.

In large networks, or when the networks topology is dynamic, a distributed approach is preferred to cope with the complexity of service deployment process. A distributed schema may work similar to hierarchical routing algorithms. In this context we have proposed a peer-to-peer solution published in [48]. We have proposed the utilization of peer-to-peer to answer the requests of clients and to construct the logical links needed to represent the overlay service network. We are inspirited of peers approach to make a distributed management of our information model. To deploy/execute a service, the client sends a request in the networks, and system management gives the equipments which can be candidates for this execution by using equipment profiles, and one service profile are created (when service is deployed). By using a super-peer approach, Profiles Model enables to represent the properties and the resources available in the super-peer domain. To represent shareable information we have introduced a new concept, the Group Profile. Thus, each super-peer gathers/maintain all the profiles of the nodes belong to under networks in an information base. This information is share among the peer nodes to decide where service must be deployed/ installed.

The phases of service deployment, by using profile model with peer approach, are as follows:

- The request arrival to a super peer node.
- Each super-peer node consults its database to know the available resources and its localizations.
- Each super-peer transmits the request to other super-nodes neighbors (forward of request). (fig.3).
- Each super-peer sends the response to the source.
- The client requests the connection with the select node(s) across intermediate peers. Fig.4.
- All the databases of resources of super-peers implied are actualized.
- Creation of service profile at database of nodes super-peer implied in deployment.



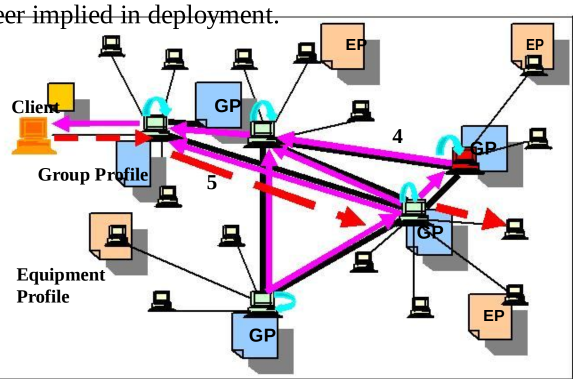




Figure 3: Group Profile notion in peer-to-peer networks    Figure 4: Service deployment with Group Profile

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Autonomic is a very important property in overlay networks. To operate in an autonomously way, overlay networks must configure themselves and automatically adapt to a changing environment. To make this automatic adaptation each node participating to overlay network needs to take local decisions. The local decisions depend on the local point of view of each node participating to overlay network. Local point of view must enable to gather information and to verify the conditions of relationships between nodes neighbours in overlay topology. Local point of view of each node is made using local data, and also data about nodes neighbours. A data abstraction is needed to represent the different information and also the data management tasks. The aggregation of local decisions enables to maintain the overlay network in accordance with the global objectives. We have proposed considerations for overlay network issues with the aim of adapting our model in this context [49].

**Profile model in virtual environments**

Future network is based in the convergence of service and communication infrastructures that will be replacing the current Internet. This approach involves providing new services, capabilities and facilities based in new approaches and not by using only the current networks technologies. Two major contexts characterize the challenges in the future networks: aware-service and network virtualization. Also QoS is a key aspect to be integrated. Services will be deployed in according with specific requests in QoS, and management of shared resources must be optimized to maintain a correct functionality of the provided solutions. QoS must to be integrated in the conception of new service generation to be able to provide self-management and QoS-aware treatments.

In this context we propose the definition of a virtual service network model to represent the virtual network in according with the QoS requirements of applications [50]. We proposed the Virtual Profiles Model such an adaptation of Profiles Model to represent the information in the deployment of virtual networks. Virtual Profiles Model aims to collect information about the resources involved in the deployment of a Virtual Networks (virtual nodes and links and their configuration). To take into account the virtualization, the service viewpoint is decoupling of physical nodes in the network. The service to be deployed is represented by the virtual nodes and links involved in the virtual network. Thus, a physical node can install several virtual nodes and support/deploy multiple services. To enable a complete virtual network proposition, considering the service and also the equipment points of views, we introduce two levels: equipment and network levels. The end-to-end virtual network solution is based in the combination of information at two levels. We introduce with this model new notions: Knowledge Profile to represent routing information at virtual level. We define also the QoS agent to incorporate QoS aspects to evaluate the non-functional properties of network elements involved in the deployment process. We consider also in our description the representation of SDN and NFV approaches. Details of the proposal are part of a current paper submission in IEEE/Globe Com 2015 conference [50].

## IV.CONCLUSION AND FUTURE WORK

The dynamic deployment of service is based on the characterization of service needs and network status. The information modeling is the first step to represent this knowledge. This paper provides an overview of approaches involved in the context of dynamic deployment of services. We analyze these approaches and present our point of view. Our main goal is to be able to facilitate the dynamic deployment of services. For this purpose Profiles model has been

proposed. Profiles Model offers the notions of profiles of service, deployment and equipment and applies the notion of service at different levels. We present an overview of our contribution with Profiles Model in the context of dynamic deployment.

More recently our work is focused in the virtualization of the network and the identification and representation of QoS for deployment and service profiles. These aspects allow us to extend our model and also represent the QoS constraints in the deployment of services, especially for cloud environments. We are working in the characterization of nodes and links in virtual environments, and also in controlling the properties to help maintain/dynamically change the relationship between the components to provide a continuous and dynamic service deployment.

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