White Paper

UPnP-QoS and Inter-MAC Interoperation in Next Generation Home Networks

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Abstract

This White Paper aims to provide an overview of two emerging technologies operating in the context of home networks, UPnP-QoS and Inter-MAC and to study how they can coexist and interoperate, in order to generate a unified common management framework in the domestic environment.

Advantages and drawbacks of such an interoperation are illustrated from a service provider's, device manufacturer's, application developer's and end user's points of view.

Keyword list – Gigabit Home Networks, Heterogeneous Technologies, Convergence layer, Quality of Service, Inter-MAC, UPnP-QoS, Middleware, Interoperation

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Problem statement

Today's Gigabit home and access networks are equipped with a multitude of devices using several wired or wireless communication technologies forming a heterogeneous environment. In this context, the main challenge facing ICT scientists and developers is to achieve an advanced management of such resources in order to deliver applications characterized by high levels of Quality of Service (QoS).

An application deployed in a networked environment generates a specific traffic flow, usually a packet-based traffic flow. In a first approach a service class based handling of the application flows is a good compromise regarding the efficiency and the complexity of implementation. This kind of mechanisms leans on the definition of several classes of services (CoS). Each ingress packet is associated with a class, and is prioritized in a differentiated way according to the class without coping with the peculiarities of the specific flow (e.g. source/destination, service characteristics as bandwidth or delay, session duration, etc.). This can be achieved by some marking at the OSI layers 3 (e.g. DiffServ) or 2 (e.g. IEEE 802.1p).

However, the approach described above only provides a macroscopic prioritization of the flows. The relatively small size of the home network makes it realistic to consider a more accurate method, based on a flow by flow handling, since the scalability concern is less critical in the home network than in the core network. This method, based on a (parameterized) description of the flow specifications, is usually associated to a resource reservation protocol. What is hinted here is that the introduction of such resource reservation mechanisms (locally in the home network and in the access network) would imply that the network supports appropriate frameworks such as UPnP-QoS or SIP. We will focus on UPnP-QoS in this document.

UPnP-QoS is the emerging standard for home networks middleware in order to allow a seamless and simple interconnection among devices with support for the establishment of QoS demanding traffic flows. UPnP-QoS is based on UPnP, which is able to bring easy-to-use, flexible, standards-based connectivity to managed and unmanaged networks whether in the home, in a small business, public spaces, or attached to the Internet. The diffusion of UPnP technology in the modern common end user devices and intermediate devices is a great driving force towards the adoption of a UPnP-QoS framework for QoS management purposes.

This White Paper deals with the concern of the interaction between the MAC layer of the home network and UPnP-QoS, which is a typical matter of interest inside the OMEGA FP7 project, with regard to the Inter-MAC mechanism currently elaborated in this project. The Inter-MAC layer is the new technology solution to obtain Gbps home networks through the interoperation of different telecommunication technologies. Thanks to its low layer network resource management capabilities, the Inter-MAC layer is able to merge the heterogeneous technologies present in the modern home network, providing to the upper layers a unique mono-technological network. Both mechanisms, UPnP-QoS and Inter-MAC, are involved in the resource management process.

These two solutions will very likely coexist in next generation home networks. The objective of this work is to provide an overview of the considered technologies (UPnP-QoS and Inter-MAC) and understand how they can coexist and cooperate in order to provide a unified common management framework in the context of home networks.

Inter-MAC overview

The Inter-MAC convergence layer ([1], [3]), designed and developed within the OMEGA FP7 project, is located between layer 2 (MAC) and layer 3 (Network Protocol) as depicted in Figure 1.

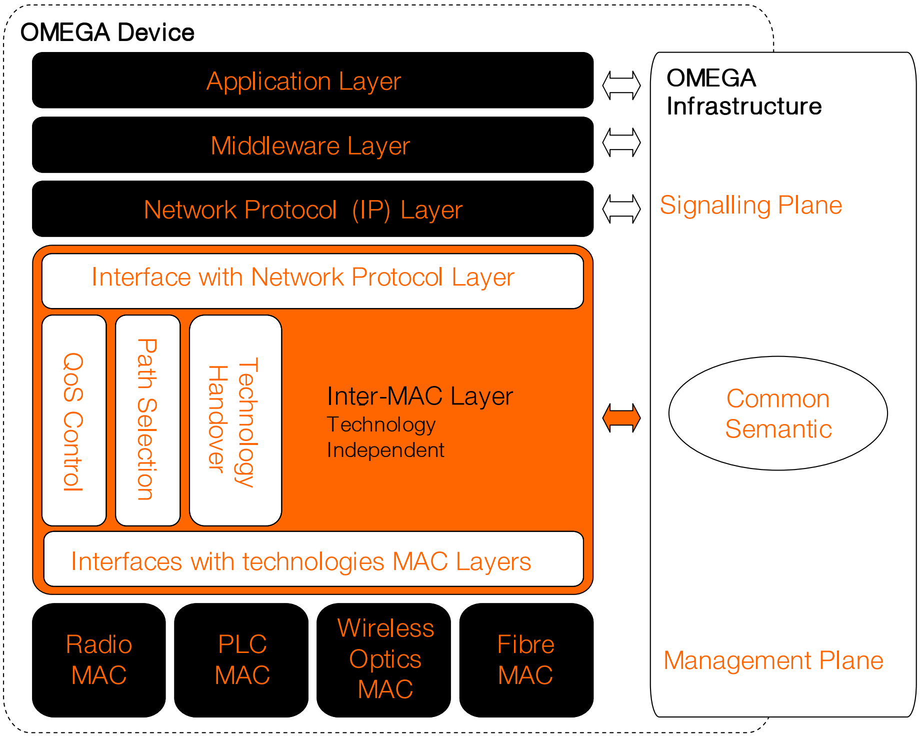

Figure 1: Inter-MAC layer stack

Such a layer allows the seamless interoperation among different telecommunication technologies, with the aim of achieving high speed rates in the home (Gbps). The Inter-MAC layer plays a key role for all inter-network communication aspects and defines a set of common semantic elements to allow information to be exchanged between each technology dependent MAC layer and the Inter-MAC layer.

Furthermore, the Inter-MAC framework provides a set of management plane elements, orthogonal in respect of the classical ISO/OSI stack layers, that can be accessed by every other layer to optimize its function. The management plane is concerned with actions that define the (typically long term) behaviour of the devices inside the network, in particular by means of a set of policies (e.g. for low-energy path selection) by the network administrator. The Inter-MAC can also access management plane elements of other layers to optimize its own function. Moreover, signalling plane elements are used to establish and release connections, execute path selection as well as to set the QoS and security parameters.

The Inter-MAC framework therefore leads to a layer 2 mesh architecture bringing in the advantages of multi-path capabilities for traffic reconfiguration. Thus it introduces a new approach for the management of Quality of Service inside the home network. The impact on the role of the different already existing or emerging management mechanisms (TR-069, SNMP, UPnP DM, LLTD, …) is low, but the Inter-MAC layer brings a real opportunity to achieve local (and remote in a further step) management of everyday operation (Operations & Maintenance, power saving). The architecture must support legacy devices and networks, and existing standards such as UPnP and SIP: the interaction of the Inter-MAC with the upper layers (above IP) must therefore be taken into account. Moreover, beyond the terminal and session mobility that can be achieved on top of the Inter-MAC layer, scenarios of inter-home continuity and multi homing may be considered.

When looking to the Inter-MAC layer architecture [2] more in detail, it can be decomposed in several engines distributed in three separated planes, the management plane, the data plane and the control plane as shown in Figure 2:

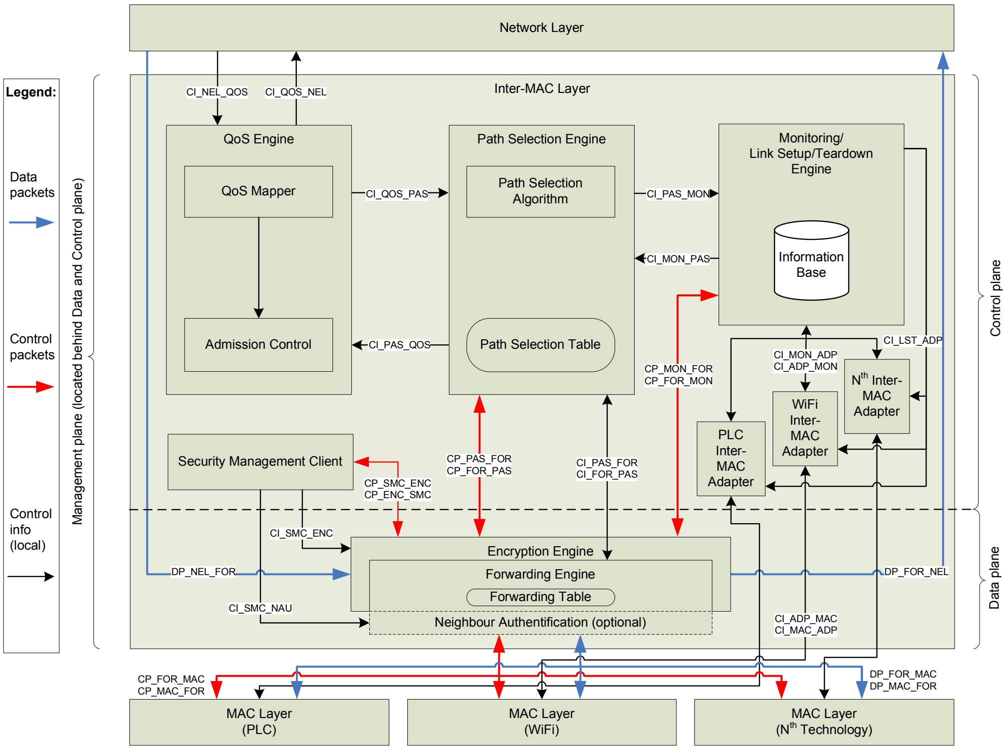

Figure 2: Inter-MAC Architecture

The black arrows in the figure represent the internal control interfaces of an OMEGA node. The labels of the arrows indicate the user and provider of the interface. The first three letters stand for the user and the other remaining letters stand for the provider of the interface, e.g. CI_PAS_FOR is the provided interface of the forwarding engine which is used by the path selection engine. The blue arrows show the flow of incoming and outgoing data packets. The red arrows represent the control packets that will be sent to the same engine in another OMEGA node.

UPnP-QoS overview

In modern home network environments, a wide variety of devices have the capabilities to interact with each other. A solution for device interfacing is proposed by the UPnP Forum [4]: Universal Plug and Play (UPnP) is a set of networking protocols to allow devices to connect seamlessly and to simplify the implementation of home networks (data sharing, communications and entertainment) and in corporate environments. UPnP achieves this by defining and publishing UPnP device control protocols built upon open, Internet-based communication standards. Two types of devices are defined by the UPnP architecture: controlled devices (or simply "devices"), and control points. A controlled device acts as a server, responding to requests from control points. Both control points and controlled devices can be implemented on a wide variety of platforms including personal computers and embedded systems. Multiple devices, control points, or both may be operational on the same network endpoint simultaneously.

The UPnP-QoS framework is designed to be a standard specification for QoS setup of traffic streams wishing to be executed in single IP subnets. The UPnP-QoS specification also supports QoS management on the LAN for traffic streams originating from or terminating in a WAN. Fundamentally, UPnP-QoS manages QoS for a traffic stream that flows between a source and a sink device in the same subnet[1] (i.e. typically the home network part of a flow). A traffic stream is viewed as a uni-directional flow from a source device to a sink device, possibly passing through intermediate devices. The UPnP-QoS specification is defined over and uses UPnP elements, in particular, the UPnP-QoS architecture:3 [6] specification defines a set of services and actions building the whole UPnP-QoS environment:

- **The QosManager:3 service** defines a set of actions for a Control Point to setup, release, and update the Quality of Service for a requested traffic stream. In a network with admission control, the role of the QosManager:3 is to admit a traffic stream to the network based on the traffic stream's requirements. It interacts with all network elements by means of the UPnP-QoS services deployed on them.
- **The QosPolicyHolder:3 service** is a repository of QoS policies for the UPnP-QoS network. The main function of this service in a prioritized network is to judiciously allocate the use of TrafficImportanceNumbers (mapped into priority indexes) by traffic streams so that traffic importance levels are not overused. When using parameterized or hybrid Quality of Service, the QosPolicyHolder:3 service also is used for contention resolution by way of a UserImportanceNumber that gets associated with a stream.
- **The QosDevice:3 service** must be implemented in a source, sink or intermediate network device. A QosDevice:3 service provides an interface towards the QosManager:3 service for QoS information retrieval and management of the resources in the device.

UPnP-QoS introduces some key concepts to describe the network topology and the related QoS management. As shown in Figure 3, UPnP-QoS defines the concepts of interface, link and technology for a QosDevice:3 service.

[1] This restriction stems from the fact that UPnP relies on multicast for service discovery. Note that the source/sink in this network not necessarily is the information/application's logical end point: a home gateway can be the end point for the QoS reservation in the home network LAN, whereas the application flow could terminate on a server in the WAN.

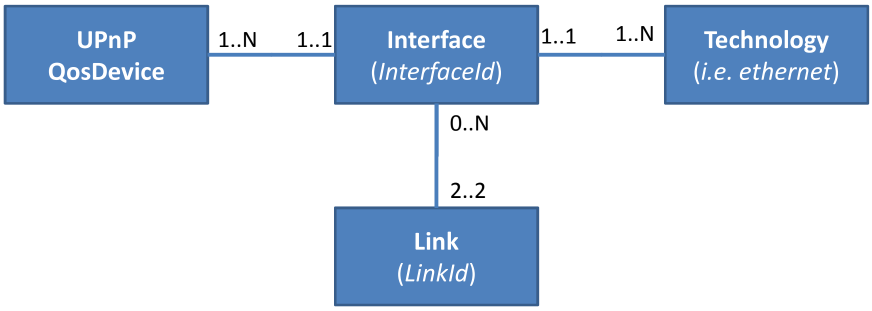

Figure 3 : UPnP-QoS interfaces and links

Every QosDevice:3 service has at least one interface which is defined as the point of interconnection between a device and a network. An interface connects to a single technology such as Ethernet, PLC or WiFi. A link is a (possibly bidirectional) direct connection between two devices for data exchange. Within an Interface, links are identified through their *LinkId*. An interface can contain multiple links. In a device, a link can only belong to one interface.

A UPnP-QoS path is composed by an ordered sequence of QosDevice:3 services, from the source to the destination.

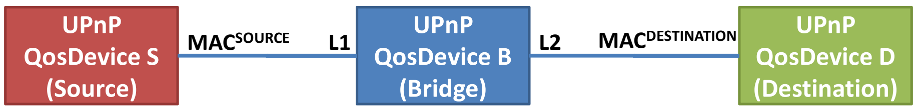

Figure 4: UPnP-QoS Path

As shown in Figure 4, a bridge is on the path if and only if it reports the MAC address of the source on a different link (L1) than the MAC address of the destination (L2) and these two links (L1 and L2) are bridged. When there are bridges without a QosDevice:3 service the complete determination of the devices path is not possible from a UPnP-QoS perspective and the QosManager:3 will consider just the parts of the path that it has determined.

A QoS segment is the subset of interconnected interfaces on the calculated path that follow the same admission mechanism.

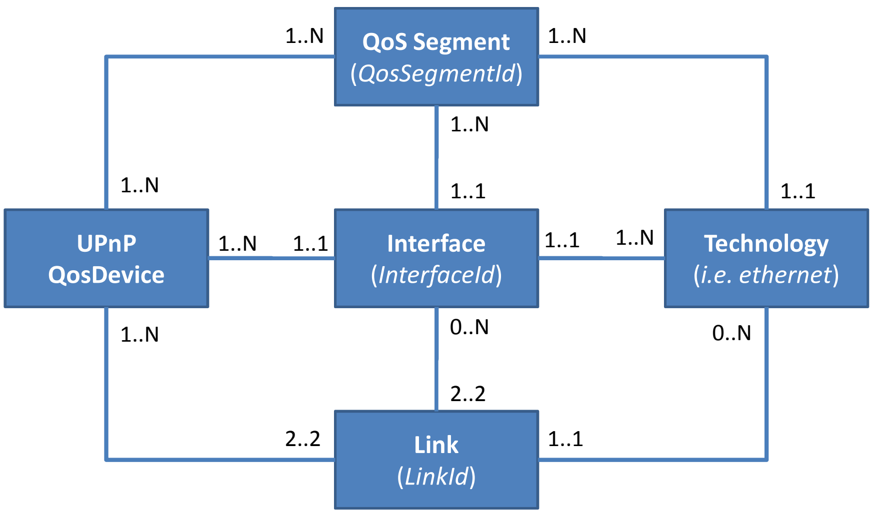

Figure 5: UPnP-QoS network concepts

The path from a source to a sink is composed of zero (this is the legacy case of non-UPnP-QoS v3 QosDevice:3 services) or more QoS segments. When a QosDevice:3 service has more than one interface and those interfaces are in different QoS segments, each interface is considered separately for

QoS setup. The concept of QoS segment is introduced to hide the Layer 2 dependencies of QoS setup on the Segment, from the QosManager:3 point of view.

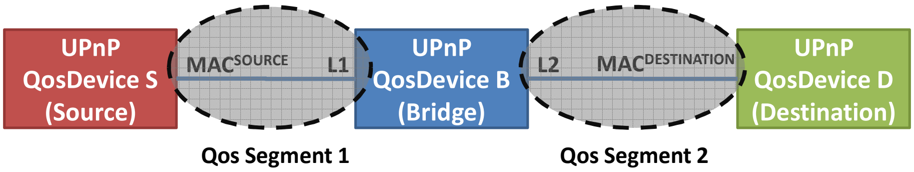

Figure 6 : UPnP-QoS QoS Segments

For example, as shown in Figure 6, the network contains two QoS Segments (QoS segment 1 and QoS segment 2). When a stream traverses both QoS Segments, both QoS Segments will require QoS setup via the QosDevice:3 services on the segments. Thus QosDevice:3 B will be asked to setup QoS twice, once for each interface. For example, suppose that QosDevice:3 S is the source and QosDevice:3 D is the destination. The path is: S then B (first the interface on the QoS Segment 1, then the interface on the QoS Segment 2) and then D.

UPnP-QoS supports three types of QoS: *Prioritized*, *Parameterized* and *Hybrid* QoS. UPnP-QoS considers 8 different Quality of Service classes (0-7), from Best Effort to High Priority classes (e.g. Audio and Video conference and Control packets). Parameterized QoS requests network resources for a traffic stream. If there is a non-parameterized QoS technology on the path, then it is not possible to setup parameterized QoS end-to-end on the entire path. Hybrid QoS addresses this issue, reserving resources in technologies that support parameterized QoS and establishing prioritized QoS on the other technology segments.

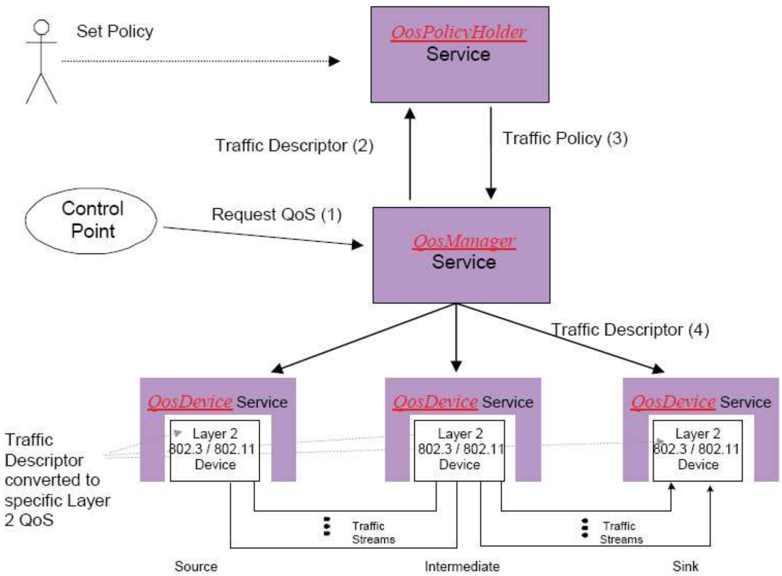

Figure 7: UPnP-QoS Architecture Overview

Figure 7 illustrates an example of a scenario that explains a basic dialogue among the UPnP-QoS entities. The Control Point application is assumed to have the knowledge of source, sink and content characteristics to be streamed. The steps to be executed described in the figure are the following:

1. The Control Point constructs a Traffic Descriptor structure and requests a QosManager:3 service on the UPnP network to setup QoS for a traffic stream;
2. The QosManager:3 service (acting as a UPnP control point) requests the QosPolicyHolder:3 service to provide appropriate policy for the traffic stream described by the Traffic Descriptor structure;

3. Based on this policy, the QosManager:3 configures the QosDevice:3 service(s) for establishing the QoS for the new traffic stream.

When the QoS setup request fails due to a lack of resources, the possibility to free resources necessary to allow the new traffic stream to be admitted, is considered. The process of taking resources from existing admitted traffic streams is called preemption. In case of preemption, the setup process is longer than the simple case, because a second attempt of reserving resources must be performed. In fact, the preemption mechanism consists of three steps: the first step is to determine which flow(s) must be preempted, the second step is to communicate to the involved devices the release or update of the previously admitted resources, and the final step is to establish the QoS of the current flow, by again executing the request process.

The main actions offered by the QosManager:3 service, which builds the basis of the whole UPnP-QoS management, are the following:

- *RequestTrafficQos()*: a Control Point invokes this action to setup QoS for a particular traffic stream. The QoS information about the stream is contained in the Traffic Descriptor passed as an argument to the QosManager:3 service. In case extended functionality such as preemption is needed, a variant of this action is *RequestExtendedTrafficQos()*.
- *UpdateTrafficQos()*: a Control Point invokes this action if it needs to change the QoS requirements associated with a particular traffic stream. The QoS information to be updated about the stream is contained in the Traffic Descriptor passed as an argument to the QosManager:3 service. In case extended functionality such as preemption is needed, a variant of this action is *UpdateExtendedTrafficQos()*.
- *ReleaseTrafficQos()*: a Control Point invokes this action to release Quality of Service for a particular traffic stream. Only a flow identifier is requested to be passed as an argument to the QosManager:3 service.

Further supported actions, detailed in [7] and providing additional UPnP-QoS capabilities, are exposed by the QosManager:3 service to a Control Point on the network: *BrowseAllTrafficDescriptors*() lists information about all stream currently admitted on the network and *GetQmCapabilities*() lists the capabilities of the QosManager:3 service, such as preemption and listing of blocking streams.

Combination Inter-MAC/UPnP-QoS

The adoption of a standard for the QoS setup of traffic streams is always a desirable solution because it increases interoperability among devices by means of: *(i)* a transparent connectivity inside the digital home, *(ii)* a unified approach for device discovery, configuration and control and *(iii)* compatible Quality of Service mechanisms.

As described in the previous sections, the Inter-MAC layer is able to manage and compose all the telecommunication resources in order to guarantee the performance level requested by the network users, while the UPnP-QoS framework performs discovery of devices in the network and coordinates their collaboration activities in a standard way, allowing simple interoperation among entities and providing a standard way for the setup of QoS demanding flows. From this consideration, it is clear that Inter-MAC and UPnP-QoS can be integrated in a common environment where they can cooperate in order to provide the required level of QoS to the application flows crossing the network, without replication of functionalities.

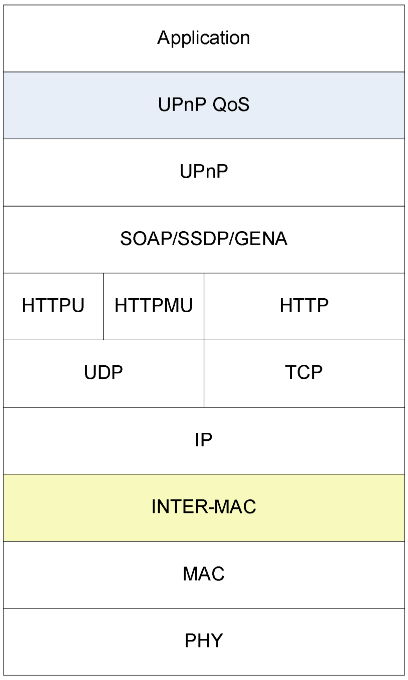

Figure 8: UPnP-QoS over Inter-MAC Protocol Stack

The cooperation between Inter-MAC and UPnP-QoS can be achieved during the establishment of QoS demanding flows. In fact, UPnP-QoS manages the application level signalling and is thus able to provide to the Inter-MAC layer the traffic information describing the flow to be initialized. Inter-MAC, on the other hand, should use such signalling information gathered from the UPnP-QoS framework in order to establish and correctly handle the flow in the OMEGA network. At the same time, the UPnP-QoS framework uses the information coming from the Inter-MAC layer to have a global vision of the network, in terms of connectivity and resources state, in a high-level detail.

In order to perform the integration between the Inter-MAC and the UPnP-QoS framework, it is needed to define the interface between them. Such interface is used by the UPnP-QoS framework to provide to the Inter-MAC information related to the flow to be established, in form of a Traffic Descriptor (containing traffic specifications specifying QoS requirements), and by the Inter-MAC layer to send information to the UPnP-QoS framework about the status of the telecommunication resources. Table 1 illustrates the complete list of actions (mandatory and optional) exposed by the QoSDevice:3 Service as specified in [7] and their relation with the Inter-MAC layer in terms of capacity of support. Analyzing the table, it is possible to distinguish support of the Inter-MAC layer in four different ways:

i) *Supported*: action actually supported by the Inter-MAC layer, at least with regard to the action's mandatory functionalities.

ii) *Missing Interface*: action not actually supported in the sense that the interface with UPnP-QoS framework is missing, but the Inter-MAC layer has the needed capabilities, at least for the action's mandatory functionalities.

iii) *Not Supported*: action not supported in terms of some mandatory functionalities that the Inter-MAC layer is not capable to provide.

iv) *Inter-MAC not involved*: action not involving Inter-MAC layer but only UPnP-QoS.

Name of QosDevice:3 Action	Mandatory/Optional	Supported by Inter-MAC
GetQosDeviceCapabilities()	Mandatory (backward compatibility)	Missing Interface
GetQosState()	Mandatory (backward compatibility)	Inter-MAC not involved
SetupTrafficQos()	Mandatory (backward compatibility)	Supported
ReleaseTrafficQos()	Mandatory (backward compatibility)	Supported
GetPathInformation()	Mandatory	Missing Interface
GetQosDeviceInfo()	Optional (backward compatibility)	Inter-MAC not involved
ConfigureRotameterObservation()	Optional	Not Supported
GetRotameterInformation()	Optional	Not Supported
AdmitTrafficQos()	Mandatory	Supported
UpdateAdmittedQos()	Mandatory	Supported
ReleaseAdmittedQos()	Mandatory	Supported
GetExtendedQosState()	Mandatory	Missing Interface
SetPreferredQph()	Optional	Inter-MAC not involved
GetUnexpectedStreamChanges()	Optional	Supported
VerifyTrafficHandle()	Optional	Supported
UpdateTrafficLeaseTime()	Mandatory	Missing Interface
SetL2Map()	Optional	Missing Interface

Table 1: QosDevice:3 service Supported Actions

From the table it is clear that the Inter-MAC layer is able to support all the mandatory functionalities required by the UPnP-QoS framework, but for a full interoperation some interfaces still need to be defined.

In general, each Level 2 technology which is under a single admission mechanism is called a *QoS segment* in the UPnP-QoS specification (e.g. a single Ethernet LAN or a single Wi-Fi network). Each QoS Segment has an associated QoS Segment ID.

If the home network is fully OMEGA compliant (all the devices composing the network implement the Inter-MAC layer), the UPnP-QoS framework can take advantage of that and its operations can be simplified due to the fact that most of the QoS related functionalities are managed by the Inter-MAC layer itself. In particular, admission control and routing functionalities are delegated to the Inter-MAC layer. In fact, thanks to the technology transparency of the Inter-MAC layer, the home environment is viewed at network and upper layers as a unique Level 2 LAN (called OMEGA network) in which each node is single-hop connected to every other node: therefore a single QoS Segment must be considered at UPnP-QoS level, as shown in Figure 9:

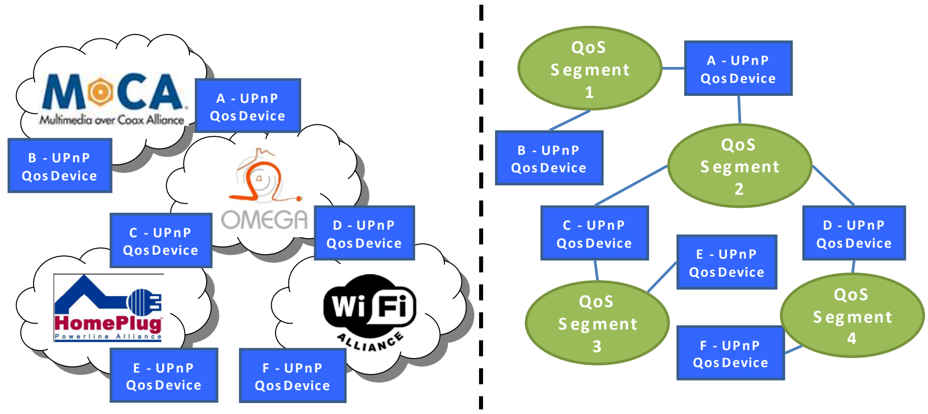

Figure 9: UPnP-QoS interprets the OMEGA network as a QoS Segment

The Inter-MAC layer generates a unique QoS Segment ID, identifying the whole heterogeneous network managed by the Inter-MAC, and only a single interface for each device is exposed: the Inter-MAC interface. Since the OMEGA network is considered as an Admission-based network, it represents an Admission-enabled segment, therefore it accepts *Parameterized* requests. The TSpec parameters provided by the UPnP-QoS framework are mapped into the 6 OMEGA QoS classes, basing on the QoS requirements that need to be satisfied.

On the other hand, in networks where not all devices are OMEGA-compliant, UPnP-QoS is essential in order to achieve an end-to-end QoS provisioning inside the home. In this case, again the Inter-MAC network is seen as a single segment by the UPnP-QoS framework, but, since it is just one of the segments constituting the entire path, UPnP-QoS is in charge of performing end-to-end admission control.

Discussion

Inter-MAC

The Inter-MAC layer has an impact on the CPU load and the link usage. The control plane is running new algorithms for path selection and QoS management in a dynamic way to keep an updated view of the network resources. On the data plane side, there is some overhead with a new 2.5 header and path selection protocol frames. That means that MTU should be managed carefully inside the OMEGA network to avoid frame fragmentation degrading performance.

For the end user, the home network running Inter-MAC will be more easy to setup, more friendly to troubleshoot and more reliable for QoS applications. It is possible to build a home network infrastructure with simple infrastructure devices running only Inter-MAC layer, without embedding higher layers such as UPnP.

However, the way an application developer or service provider interacts with the Inter-MAC layer to take advantage of its functionality can be simplified by using a higher level policy and resource management framework.

UPnP-QoS

UPnP-QoS provides a policy based QoS management framework for the home network. This means that the quality of consumer services can be managed easily and policies can be configured according to the subscriptions a user has subscribed to.

One of the biggest advantages of UPnP-QoS is that it provides an abstraction layer towards all possible admission mechanisms. Functionality specific to a certain networking technology is bundled in the QosDevice:3 service implementations. The generic management functionality will not need to be changed when a new device or networking technology gets added to the home network.

However, UPnP-QoS is limited to QoS on a single subnet and assumes there is only one path between each source and destination device. Furthermore, for devices to be manageable by the UPnP-QoS management framework a QosDevice:3 service (a minimum of one QosDevice:3 service per QoS segment is needed) needs to be implemented.

Combination

Even if the UPnP-QoS framework and the Inter-MAC layer have been designed independently one from the other, their combination in a home network is possible, as described in previous sections.

Even more, since these frameworks address complementary issues, their interoperation in a home network brings the following advantages:

- UPnP-QoS allows to extend the QoS management and control capabilities offered by the Inter-MAC layer even when legacy (i.e. no Inter-MAC enabled) networked elements and devices are present in the home network;
- UPnP-QoS allows a simple means to communicate application level QoS requirements;
- The Inter-MAC layer allows to simplify the operation of the UPnP-QoS framework. In fact, the Inter-MAC layer hides the heterogeneity of the home network which is seen by the UPnP-QoS framework as a single QoS segment. This also implies that only an Inter-MAC dependent QosDevice:3 service will be necessary, without the deployment of a specific QosDevice:3 for each MAC technology used in the home network. The direct consequence is that in an OMEGA network the UPnP-QoS framework is easily deployable because much of the complexity is hidden in the Inter-MAC layer;

- Some QoS management functionalities have been already implemented in the Inter-MAC layer, (for instance the application flows' importance and priority management functionalities offered by the UPnP QoS Policy Holder), thus the UPnP-QoS framework architecture can be simplified, consequently the deployment of the UPnP-QoS functionalities in low cost, mass-scaled network devices is foreseen;
- The whole integrated framework (UPnP-QoS + Inter-MAC) allows to provide easy and standardized QoS management and control in heterogeneous gigabit home networks, in a way that is transparent for the user and its applications.

Of course, all those advantages do not come for free. A specific interface has to be included in the Inter-MAC layer to allow the exchange of control messages with the UPnP framework. Such an interface has been already defined during Inter-MAC layer design, and it is called *"CI_NEL_QOS"* (as shown in Figure 2). The actual design of this interface covers only general message exchange since it was not explicitly designed for the communication with the UPnP-QoS framework. A detailed design of that interface is still needed to extend its capability to make UPnP-QoS and Inter-MAC layer fully interoperate.

Viewpoints

This section discusses pros and cons of the combination of Inter-MAC and UPnP-QoS technologies from the viewpoint of every actor, such as service providers, device manufacturers, application developers and end users.

Service Provider

An easy installation and a high Quality of Service are two major stakes from a service provider point of view. Clearly UPnP aims at realizing such an easy installation, and the Inter-MAC framework favours a high Quality of Service. Moreover the Inter-MAC is applicable in the middle term not only to "no new wires" solutions but also to solutions based on structured cabling (such as Ethernet cabling or optical fibre). In the prospect of a changing home network where Inter-MAC devices and UPnP (not Inter-MAC) devices might coexist, the UPnP-QoS framework would allow to maintain an overall control of the Quality of Service performance, while keeping a reasonable degree of simplicity due to a simplification of the UPnP-QoS framework by the Inter-MAC.

More generally the specific issue tackled in this White Paper highlights the interest of studying the possible interaction between the physical/MAC layers and the upper layers.

Device Manufacturer

For device manufacturers easy installation and supporting high Quality of Service with low resource consumption and low cost, mass scaled network devices are very important. The combination of Inter-MAC layer with UPnP-QoS allows to simplify the UPnP-QoS architecture and operation, which supports strongly the above mentioned requirements.

A negative side effect for a device manufacturer is that you have to support two QoS frameworks which will increase process costs for update procedures, versioning, documentation, service and maintenance processes.

From the point of view of a manufacturer that provides the end user several different devices that can be used in a home network, such as access gateways, Wi-Fi routers, network switches and Set Top Boxes, it seems mandatory to spend some effort in the development of technologies that help the end user in setting up an adequate network infrastructure. From this point of view, a solution based on the combination of UPnP-QoS and Inter-MAC seems to be quite promising, even when taking into account the negative effects previously mentioned.

Application Developer

The QosManager:3 service provides a well-defined and simple interface towards the QoS management framework from an application perspective. The fundamental input needed by the UPnP-QoS framework to perform its Quality of Service functionalities is represented by the TrafficDescriptor, which defines the application flow QoS requirements. Therefore, the application layer simply needs to compose the TrafficDescriptor argument and invoke the UPnP-QoS framework (i.e. the QosManager:3 service) by means of a Control Point. In order to drastically simplify application implementations, a generic Control Point that receives input from an application and handles all communication with the QosManager:3 service can be designed.

End User

The end user shouldn’t be bothered with network management and as UPnP offers dynamic discovery and configuration of compliant devices, the end user should only have to power on the device.

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