Enabling Network Mobility by Using IEEE 802.21 Integrated with the Entity Title Architecture

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Abstract. *This work presents the integration of the IEEE 802.21 framework with the Entity Title Architecture (ETArch), a clean slate approach that is deployed atop OpenFlow. In the resultant architecture, network mobility is provided within the Workspace, a logical channel able to gather multiple communicating participants. This paper describes the main architecture components and the signaling approach deployed in a handover scenario by providing the details the integration between 802.21, OpenFlow and Entity Title Control protocols.*

1. Introduction

Current applications and devices, such as smartphones, bring a new set of requirements, such as mobility, that the Internet is not able to satisfy in a proper way [Zahariadis et al. 2011]. To appropriately handle vertical mobility, the handover process must consider different access technologies currently available in these devices. The IEEE 802.21 standard for Media Independent Handover (MIH) [Corujo et al. 2011] provides a set of media-independent primitives that creates an abstraction regarding the link layer.

In this work we describe at a glance the protocol approach of the Entity Title Architecture (ETArch), a clean slate Future Internet architecture that applies new naming and addressing schemes based on the Title, a topology independent designation that ensures an unambiguous identification of an entity [Pereira et al. 2011]. Through ETArch, communications are handled by the Workspace, a channel which aims at gathering multiple communicating participants. Therefore, ETArch inherently allows the integrated support of multicast and mobility within the Workspace.

The remainder of the document is organized as follows: Section 2 presents an overview of ETArch and its control protocol. Section 3 presents the integration of ETArch

and the IEEE 802.21 framework, exploring a scenario where its mechanisms are used to optimize mobility processes and, finally, section 4 presents concluding remarks and future work.

2. Entity Title Architecture Overview

The Entity Title Architecture (ETArch) is a realization of the Entity Title Model [Pereira et al. 2011]. The Title Model is a vision of how entities should be able to semantically specify their requirements and capabilities in order to communicate with each other. On a previous work [Silva et al. 2012], we presented the main concepts of this architecture and its protocol stack.

An important concept at ETArch is the workspace. The workspace is the channel aiming at to gather multiple communicating participants at the same time. It can be viewed as a logical bus interconnecting multiple entity instances (e.g., a service, a sensor, a smartphone, a host, or even a process).). Its behavior is inspired by the multicast technology, where the data is sent once by a source to the workspace, and all associated entities will receive. This scheme allows an efficient use of the physical layer [Silva et al. 2012].

To support the workspace concept, new protocols in the data and control plane have been defined. In the control plane, the signaling approach provides the services related with the life cycle of entities and workspaces, such as to register an entity at the Domain Title Service (DTS) or to create a workspace, attach and detach entities to a given workspace. The Entity Title Control Protocol (ETCP) is responsible for the communication between an entity and the Domain Title Service Agent (DTSA), while the DTS Control Protocol (DTSCP) is responsible for the communication between DTSAs inside the DTS. Table 1 summarizes the primitives defined by the ETCP and how it is deployed atop OpenFlow, with section 3 showing this integration.

Table 1. Entity Title Control Protocol (ETCP) Primitives.

Primitive	Semantics	Relation with OpenFlow
ENTITY-REGISTER	Registers an entity at the DTS. To be registered, an entity must present its title, capabilities and communication requirements. To communicate, the entity must first register itself. The registration is handled by the closest DTSA.	Request is Encapsulated in an OFPT_PACKET_IN message and the response in a OFPT_PACKET_OUT message
WORKSPACE-CREATE	Creates a workspace locally at the DTSA. Upon the reception of this primitive, the DTSA will advertise the workspace by inserting an entry at the Workspace Database.	By using an OFPT_FLOW_MOD message adds a new flow identified by a specific Workspace Title
WORKSPACE-ATTACH	Attaches an entity to a workspace. To accomplish the attachment process, the DTSA will obtain all network elements and will configure them to extend that workspace.	By using a OFPT_FLOW_MOD, the entity phisical port is defined as a destination for the data transmitted in that worskpace
ENTITY-UNREGISTER	Removes an entity from the DTS.	The same behavior of ENTITY-REGISTER
WORKSPACE-DETACH	Removes an entity from a existing workspace and updates workspace at the DTSA and Network Elements.	Uses an OFPT_FLOW_MOD, to remove the physical port where this entity is connected. Response is encapsulated in an OFPT_PACKET_OUT
WORKSPACE-DELETE	Deletes a workspace and performs all clean up necessary at the Network Element of the current DTSA.	Uses an OFPT_FLOW_MOD, to remove all the physical port where this entity is connected.Response is encapsulated in an OFPT_PACKET_OUT

3. IEEE 802.21 Integration

To support vertical handover optimization between different access networks, ETArch will use the IEEE 802.21 framework through an integration with its open source implementation, ODTONE [Aguiar et al. 2011]. This integration will enable the DTSA to

communicate using not only the OpenFlow protocol but also using the MIH Protocol [Corujo et al. 2011] from the IEEE 802.21 standard. This approach will enhance the information exchanged between network entities and terminal nodes, seeking to control entities to be aware of available wireless networks detected by mobile nodes, their link parameters and conditions, and use this information to optimize handover processes. The integration architecture is presented in Figure 1 and its the main components are:

- *DTSA* - The DTSA, which acts as an OpenFlow controller, is a vital part of the overall ETArch architecture. DTSA uses the OpenFlow protocol and also the MIH protocol to comunicate with the Network Elements (NE). This allows the DTSA to optimize and control the handover process of terminal nodes, as well as allowing the control of the flow tables of each OpenFlow Switch.
- *EDOBRA Switch* - The EDOBRA switch is responsible for executing data packet forwarding operations. It holds a ow table that stores ow entries, containing information on how to process each data ow. The information on the flow table is defined by an external entity (i.e., the OpenFlow controller) and, therefore, it contains an OpenFlow Protocol peer that enables the communication with the DTSA via the OpenFlow protocol. Lastly, it provides a MIHF (with the respective interfacing Service Access Points - SAPs), enabling the interface with the DTSA for management operations.
- *Mobile Node (MN)* - Represents the end-user equipment allowing the user to connect to the network. The MN is provided with one or more access technologies, usually wireless. The MN is coupled with a MIHF, along with interfaces towards the access links (i.e., MIH Link SAPs) and interfaces towards higher-layer entities, facilitating the control and information retrieval from the links in an abstract way. This interfacing can be done in a remote way via the MIH Protocol exchanged between MIHFs of remote entities, but can also be achieved by existing MIH-Users in the MN itself. Concretely, the MN is coupled with a Mobility Manager module to assist in mobility-related mechanisms. In what concerns DTS procedures, such as register and workspace creation and attachment operations, the MN contains a DTS Enabler (socket), which allows the MN to communicate with the EDOBRA switch.
- *Source Node* - The Source Node is responsible for creating the workspace and to publish contents in it. Like the MN, it contains a DTS Enabler (socket) to manage the procedures related with the DTS.

3.1. Mobility Scenario

This section describes the use case that illustrates how ETArch optimizes the mobility control process through IEEE 802.21, by providing information about nearby handover candidates and facilitating the handover with technology-agnostic commands able to trigger the L2 attachment and necessary DTS procedures.

Figure 2 presents the bootstrap of the scenario illustrated. It encompasses the steps of registering entities with the DTSA and the creation and attachment to workspaces.

Before being able to publish or receive media, an entity must be registered with the DTSA of its domain. To be registered, an entity must present its title and communication requirements to the DTSA, so it sends an *ENTITY-REGISTER.req* primitive, which will be forwarded by the NE to the DTSA using the OpenFlow *OFPT_PACKET_IN*

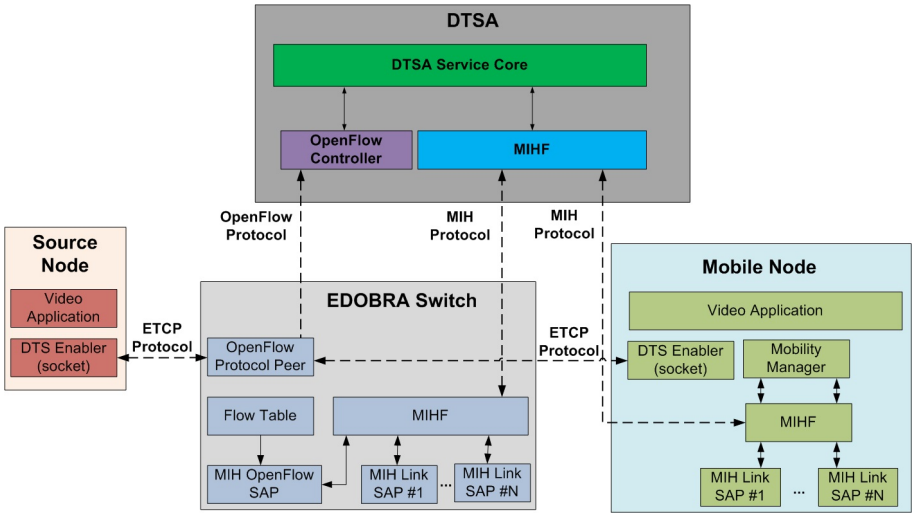

Figure 1. DTSA and ODTONE Integration Architecture.

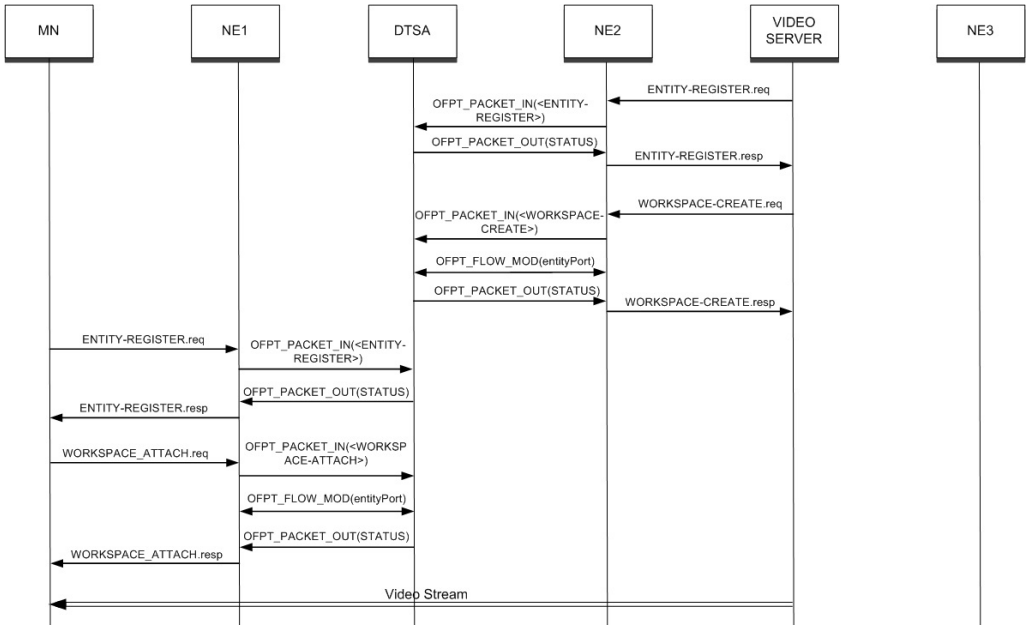

Figure 2. Scenario bootstrap.

message. The DTSA will reply with the status of the operation using an OpenFlow *OFPT_PACKET_OUT* message that will be translated into an *ENTITY-REGISTER.resp* and delivered to requesting entity.

An entity that intends to provide a new media requests the *WORKSPACE_CREATE.req* primitive. This message will be forwarded by the NE to the DTSA, using the OpenFlow *OFPT_PACKET_IN* message. The DTSA will receive this indication will create a new workspace identified by its title and associated with a flow identification. By using the OpenFlow *OFPT_FLOW_MOD* message, this rule will be added to the flow table.

Then, a registered entity that wants to receive the media provided by the workspace, should attach to it by requesting a *WORKSPACE_ATTACH.req* primitive. This

primitive will also be forwarded to the DTSA and in the same manner, by using the OpenFlow *OFPT_PACKET_IN* and *OFPT_FLOW_MOD* messages, will modify the flow table to include the physical port of the requesting entity into the current workspace. In the end of the attachment procedure the entity will be able to receive the media provided by the workspace.

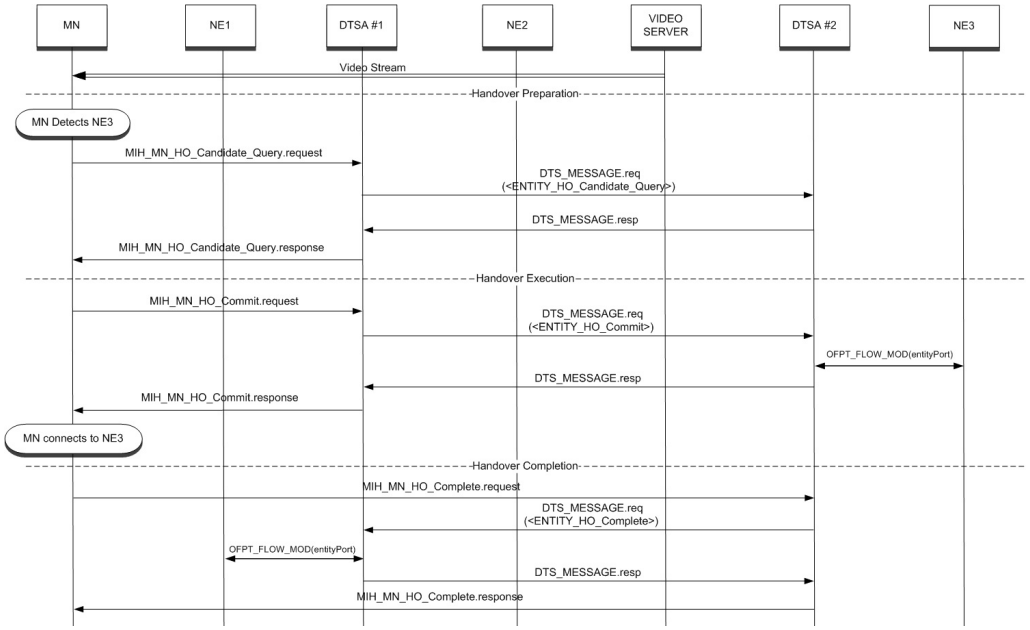

Figure 3. Handover Assisted by the Mobile Node, controlled by the Network between different DTSAs

The MN detects a better network to receive the video feed (e.g. the network that belongs to the NE3) and issues a MN-initiated handover, using the MIH protocol, by sending a *MIH_MN_HO_Candidate_Query.request* message to its current DTSA. The DTSA#1 verifies that the destination NE does not belong to its domain and, therefore, it sends a *DTS_MESSAGE.req (ENTITY_HO_Candidate_Query)* message to the DTSA that owns the NE3. Upon the reception of this message, the DTSA#2 checks internally if it has the resources needed to accommodate the new MN and its subscribed workspaces, sending the response to the DTSA#1 which, for its part, forwards the status to the MN (*MIH_Net_HO_Candidate_Query.response* message).

The MN verifies if the NE3 is still feasible and, if so, it notifies the DTSA#1 about the selected target network, sending a *MIH_MN_HO_Commit.response* message, which will forward the request to the DTSA#2 via *DTS_MESSAGE.req (ENTITY_HO_Commit)* message. The DTSA#2 registers the entity and performs a workspace attach. The attachment may invoke a *DTSA_WORKSPACE_LOOKUP* procedure for adding NE3 to the workspace. When the resources are committed, the DTSA#2 acknowledges the MN, via DTSA#1, that the resources were reserved and that the MN can move to the new network. Upon the reception of this message, the MN executes the attachment to the NE3 network. Starting from this moment, the MN belongs to the DTSA#2 domain and, therefore, it becomes its new PoS (Point of Service).

Thus, after the handover procedure, the MN informs the DTSA#2 of its result, by sending a *MIH_MN_HO_Complete.request* message. The DTSA#2 forwards this message

to the DTSA#1, via *DTS_MESSAGE.req (ENTITY_HO_Complete)* message, in order to inform the old MN's DTSA that the MN is no longer in its domain. Then, the DTSA#1 requests the NE1 to release the resources and subscriptions associated with the MN (*OFPT_FLOW_MOD(entityPort)*).

4. Concluding Remarks and Future Work

This work presented an integration between the Entity Title Architecture (ETArch), a clean slate Future Internet architecture, and the IEEE 802.21 framework to achieve media independent optimized mobility between different wireless access technologies.

ETArch is built upon an abstraction of current networks by using OpenFlow and IEEE 802.21 protocols. While OpenFlow abstracts the control of Network Elements, specially wired ones, the IEEE 802.21 provides an abstraction of wireless network access technologies, thus enabling a common control (the DTSA) to build a new communication approach by using the workspace.

This abstraction will be available to other research groups, contributing and fostering new research regarding SDN based network architectures and also Future Internet research and experimentation.

The next step of this work is to deploy and experiment this scenario in the OFELIA island that will be deployed in Brazil within the EDOBRA (Extending and Deploying Ofelia in BRAzil) project [OFELIA 2012].

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