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IEEE 802.21: A Shift in the Media Independence

Antonio DE LA OLIVA[1], Lucas EZNARRIAGA[2], Carlos J. BERNARDOS[1], Pablo SERRANO[1] and Albert VIDAL[3]
[1]*University Carlos III of Madrid, Avda. de la Universidad 30, Leganés, 28911, Spain*
Tel: +34 91 6248803, Email:aoliva, cjbc, pablo@it.uc3m.es
[2]*Institute IMDEA Networks, Avda. del Mar Mediterrneo, 22, Leganés, 28911, Spain*
Tel: +34 91 6248803, Email:lucas.eznarriaga@imdea.org
[3]*Fundación I2CAT, Campus Diagonal Nord. Edificio NX (Nexus I). C. Gran Capitá, Barcelona, 08034, Spain*
Email:albert.vidal@i2cat.net

Abstract: In this paper we present our vision on future uses of the Media Independence paradigm developed within the IEEE 802.21. We argue that this specification is an excellent starting point for future applications that require the handling of heterogeneous technologies. The current IEEE 802.21 standard facilitates media independent handovers by providing higher layer mobility management functions with common service primitives for all technologies, thus hiding the technology specifics of the lower layers. In this paper we claim that such a media independent abstraction can be useful for functions other than handovers and advocate for extending the IEEE 802.21 standard to cover these additional functions. We concentrate on a particular scenario currently being discussed in the 802.21 WG, the Spectrum Optimization & White Spaces. We first identify the key challenges that need to be addressed in order to satisfy the requirements of these scenarios by means of a media independence abstraction. Then, based on the requirements identified, we outline a proposal for a media independent service layer architecture.

Keywords: Media Independence, Abstraction, IEEE 802.21

1. Introduction and Motivation

Recently the work performed within the Media Independent Handover Services group of the IEEE has been approved as the IEEE 802.21[1][2] standard. The main purpose of IEEE 802.21 is to enable handovers between heterogeneous network access technologies (including IEEE 802 and cellular technologies) while maintaining service continuity, hence improving the user experience of mobile terminals. This standard opens a new set of possibilities in the field of mobility across heterogeneous networks.
The novelty of the IEEE 802.21 specification is that it defines a technology-independent abstraction layer able to provide a common interface to upper layers, thus hiding technology specific primitives. In particular, 802.21 provides new functionality for inter-technology handover by defining an abstraction layer which is used by upper layers to interact with different link layer technologies in an homogeneous way. The strategic concept introduced by the IEEE 802.21 standard is the Media Independence paradigm. This concept is very attractive, as it allows hiding the complexity of each technology behind a set of standardized primitives thereby reducing the complexity of higher layers. This increases the number of lower-layer capabilities that are accessible without technology- or driver-specific adaptation, hence improving the reusability of code and reducing the necessary development and maintenance cost.

The key contribution of this paper is to advocate the use of the Media Independence paradigm for other purposes in addition to handovers. We argue that it would be highly desirable to enable the use of a set of standardized mechanisms to provide Media Independence to other applications. Following these lines, we propose a shift in the current perspective of IEEE 802.21, enabling and extending it to be used in other scenarios different from the handover use case.

The authors of this paper have already started to discuss, within the IEEE 802.21 WG, the application of the Media Independent paradigm to other scenarios. One of the applications that have been considered is dynamic spectrum optimization, mainly focused on White Spaces [3][4]. Following the above application discussed in the 802.21 WG, in this paper we analyze their requirements and derive a set of functions that can satisfy these requirements by using the media independent concept of 802.21. Although these functions are highly focused on the scenario considered, we believe that they can serve a much broader set of applications, and consider that this is a first step towards a truly generic Media Independent Services interface.

The remainder of the paper is structured as follows. Section 2. presents the applicability scenario in which we focus, namely Spectrum Optimization & White Spaces (section 2.1). After the description of the scenario, we focus on presenting the set of new functionalities which, in our opinion, could benefit from media independence (section 2.2). Based on the required functionalities and evolving the Media Independent Layer proposed in IEEE 802.21, in section 3., we propose a new architecture for a Media Independent Service Layer (MISL), focusing on its reference model. Finally section 4. concludes this work.

2. Scenarios and Requirements

This section presents a possible deployment scenario where the Media Independent Services can be used to abstract the technology heterogeneity. At the time of writing this work, a clear scenario have been identified by the IEEE 802.21 WG, the Spectrum Optimization & White Spaces. We argue that the use of a Media Independent Services abstraction layer is required for the success of this technology. In the remainder of this section we present this scenario.

2.1 Spectrum Optimization & White Spaces

The IEEE P1900 Standards Committee (SCC41[1] since 2007) was established in 2005 with the aim of developing standards for next generation radio and advanced spectrum management, with special attention to the improvement of the spectrum usage by developing dynamic allocation techniques.

One of the WG of SCC41 is the IEEE 1900.4, which studies cognitive spectrum management. The cognitive spectrum management concept applies the cognitive radio paradigm to spectrum usage, enabling spectrum to be shared and dynamically managed between all the players to improve its overall use and increase the performance of the radio access. These techniques require interference management, wireless technologies coordination, network management and information sharing.

In February 2009 the IEEE 1900.4 standard [3] was completed. This standard aims at improving the overall capacity and quality of heterogeneous wireless access networks by

[1] Standards Coordinating Committee

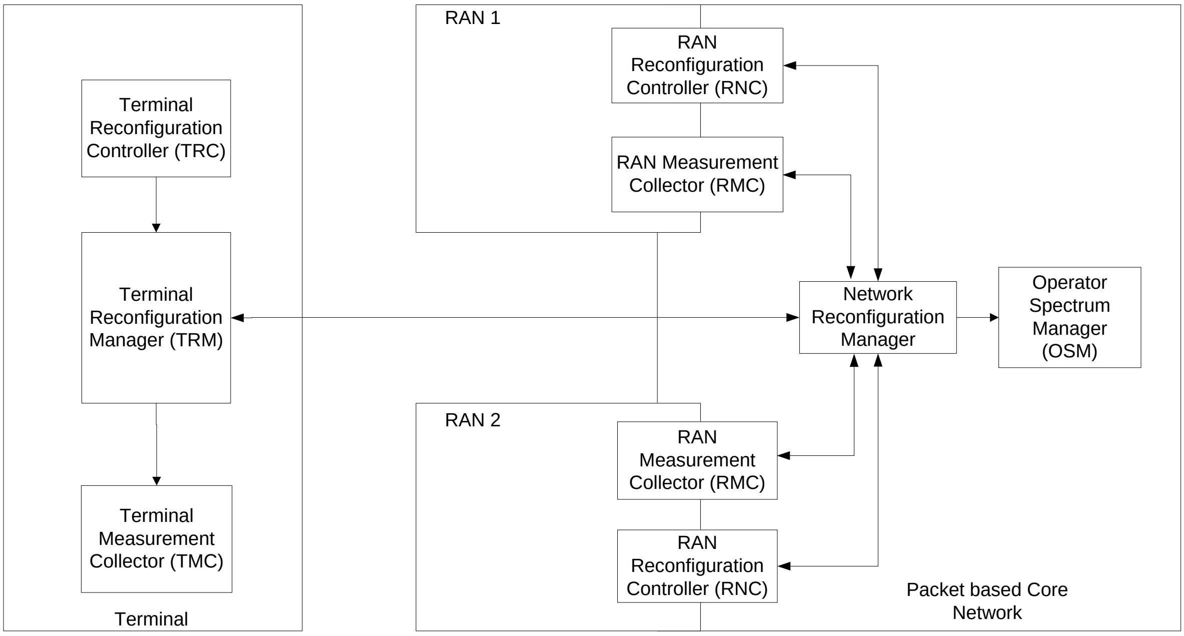

Figure 1: IEEE 1900.4 System Architecture

developing the appropriate architecture and protocols to facilitate the optimization of radio resource usage. This requires, in particular, communication between the terminal and the network to allow coordinated network-device distributed decision making for radio resource optimization.

The IEEE 1900.4 standard defines the overall architecture required for dynamic spectrum usage, the information to be exchanged and the reference use cases at functional level. The main building blocks of this architecture are depicted in figure 1. The architecture comprises several modules both in the network and terminal sides.

The modules in the terminal consist of measurement and radio configuration modules. The Terminal Measurement Collector (TMC) is the module in charge of gathering context information providing it to the Terminal Reconfiguration Manager (TRM). The TRM is the entity managing the distributed optimization of radio resources in the terminal side, the specific configuration commands are issued to the Terminal Reconfiguration Controller (TRC) which controls the reconfiguration process in the terminal. Each of above entities has a corresponding peer on the network side. The modules in the network are spread over the Radio Access Network (RAN) and the IP core network. Modules in the RAN are the RAN Measurement Collector (RMC), which plays the same role as the TMC in the terminal, and the RAN Reconfiguration Controller (RRC), which performs the RAN reconfiguration processes.

The spectrum optimization process is distributively performed between the network and the terminal and is controlled by two entities located at the IP core of the network: the Network Reconfiguration Manager (NRM) and the Operator Spectrum Manager (OSM). The NRM is in charge of managing the distributed spectrum optimization process and the different RAN technologies. The OSM is the entity which enables the operator to control the decisions taken by the NRM.

The standard also defines a set of three scenarios where dynamic spectrum optimization is useful. These three scenarios correspond to:

- Dynamic spectrum assignment, where the available spectrum is dynamically assigned to the participating RANs depending on their requirements.
- Dynamic spectrum sharing, where the available bandwidth assignment is fixed but several RANs can share the same spectrum band. This is the use case enclosing the White Spaces scenario.
- Distributed radio resource optimization, where the network configures the terminals to improve spectrum usage and quality of service.

Note that the second of the above scenarios encompasses White Spaces, where unlicensed technologies can use the white spaces left by licensed technologies such as TV broadcast in their respective spectrum bands.
The standard also specifies how to perform spectrum optimization by defining six generic procedures which are required for dynamic spectrum usage:

1. Collecting Context Information
2. Generating spectrum assignment policies
3. Making spectrum assignment decision
4. Performing spectrum access on network side
5. Generating radio resource selection policies
6. Performing reconfiguration on terminal side

Procedures 1, 4 and 6 correspond to the message transfer and configuration of several parts of the access network and terminal. The IEEE 802.22 [5] standard is being developed to assist these functions by means of cognitive radio techniques. However, these techniques are complex and lack support for heterogeneous technologies. We argue that a simpler and more effective way of supporting these procedures would be by means of a Media Independent Services functionality based on the existing IEEE 802.21 approach that provides an abstraction layer that hides the specifics of each technology. This would further help in the successful deployment of IEEE 1900.4 ideas in heterogeneous environments.
The possible use of IEEE 802.21 mechanisms to provide the functionality required by IEEE 1900.4 has been presented in the IEEE 802.21 WG by authors of this work [6], and it is currently being discussed.

2.2 Requirements for a Media Independent Services Layer

The previous section presented the description of a scenario were we have identified the need for a Media Independent Services Layer. This scenario requires some kind of abstraction layer to be able to cope with the heterogeneity of the radio access network. Based on the properties of the scenario, we have extracted a set of functionalities. From this, we obtain the following list of consolidated functionalities that the Media Independent Services Layer must implement:

- Self description of interface properties: Primitives allowing the self discovery of capabilities.

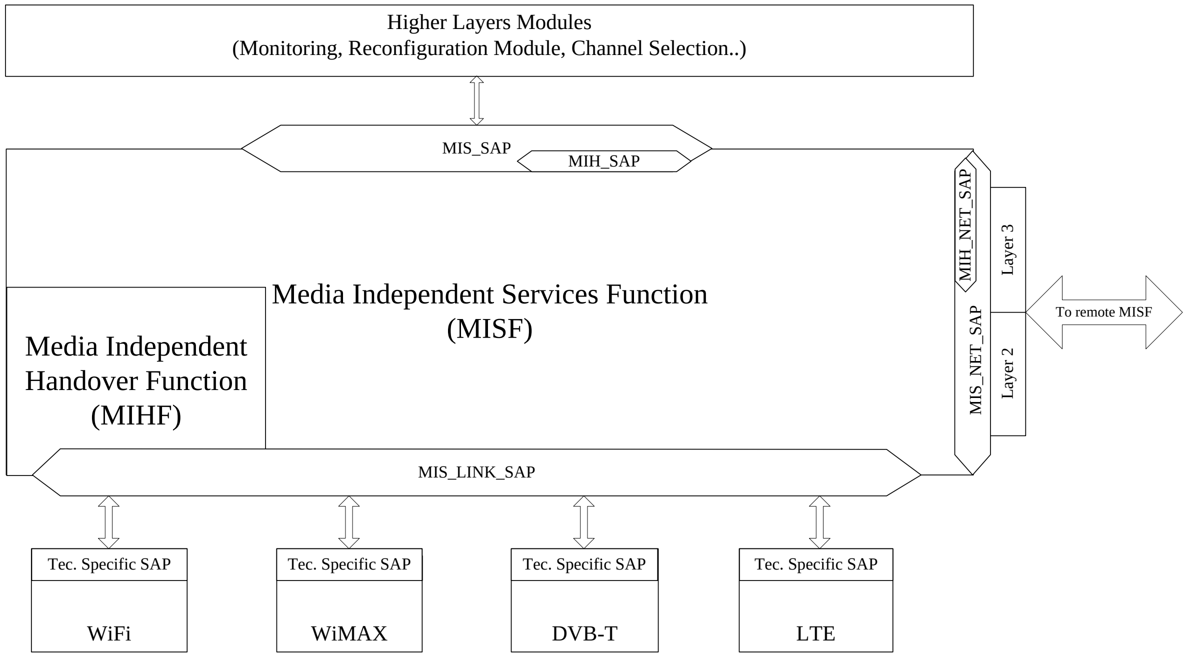

Figure 2: Media Independent Services Layer Architecture

- Configuration of radio interfaces: Primitives that allow to control channels, transmission characteristics, etc.
- Neighbour discovery: Primitives allowing the discovery of neighbours via active and passive techniques.
- Auto-negotiation of radio parameters: Peer to peer negotiation of radio parameters with neighbours.
- Creation of new Links: Primitives enabling a common way of setting up links with neighbours using different technologies.
- Monitoring the network and radio interfaces: Primitives to measure the performance of the network in a common way and definition of new thresholds for parameter reporting.

In the following section we focus on providing an architecture extending the IEEE 802.21 framework to enable the set of functionalities explained above. It is worth to notice that the required abstractions to support these functionalities are out of the scope of this work and require further research.

3. A Media Independent Service Layer Architecture Proposal

In the previous sections we have analyzed the requirements of a Media Independent Services Layer to handle the heterogeneity of access networks. This section presents an architecture developed as an extension of IEEE 802.21 to provide the required functionality.

Figure 2 presents the proposed architecture. It is based on IEEE 802.21 so it retains the same global ideas and service access points (SAPs). The main block corresponds to the Media Independent Services Function (MISF), which aims at providing a framework to facilitate the interaction between higher layers and lower layers in an abstract way. The MISF provides three sets of services inline with the IEEE 802.21 event, command and information services but incorporating the new primitives required. For this reason, IEEE 802.21 is included in the architecture as a subset of the MISF, providing abstract services for handovers. In particular, the service access points are also maintained as much as possible.

The architecture defines three SAPs: i) the MIS_SAP which communicates the MISF with the upper layers protocols or modules, ii) the MIS_LINK_SAP communicating the MISF with the lower layers following an abstract media dependent interface and iii) the MIS_NET_SAP which allows remote communication between MISF entities. All these SAPs are supersets of the IEEE 802.21 SAPs, namely MIHF_SAP, MIH_LINK_SAP and MIH_NET_SAP, although with the appropriate extensions.

One of the problems that we have identified with IEEE 802.21 is the Mobile Node centric approach followed by this standard. Current IEEE 802.21 architecture focuses on the Mobile Node (MN), and the rest of the Media Independent Handover (MIH) network entities are defined based on their relation to the MN. In this architecture, only a subset of the nodes in the network are IEEE 802.21 capable, since the functionality required in the network to facilitate handovers is limited. Even more, the communication reference model of 802.21 situates the MN as the central point of the communication, which can only talk with certain nodes located in the network, but never with other MNs. In the case of a generic MISL, it is probable that the nodes in the network have a peer relationship, being equal, hence the MISL must allow communication between peer entities, and also between nodes and management entities in the network.

In order to solve this issue, we present the reference model in figure 3, which updates the one considered in IEEE 802.21. The reference model is based on different entities depending on the communication role they assume:

- A node (N) is the entity being served.

- A Point of Association (PoA) is a node which can be reached through direct L2 connection from N, which includes point of attachments as an IEEE 802.11 access point and neighbouring nodes. Note that this definition comprises neighboring nodes which have already established an L2 connection with N and neighboring nodes which do not have established the L2 connection yet. Note that direct communication with a PoA to which N has not established an L2 connection can be done via L2 specific management frames or L3 using other interface.

- A Point of Service (PoS) corresponds to an entity which is serving directly node N, in the case of a mesh network, all mesh nodes are possible PoS.

- The non-PoS entity plays the same role as in IEEE 802.21, it is an entity which can directly exchange messages with another MISL entity but it cannot directly exchange messages with the MISL entity located at the MN. As an example it can be an Information Service which is accessed by a PoS to provide information to the MN.

- Finally a non-PoA corresponds to a node which does not have a direct L2 communication with N.

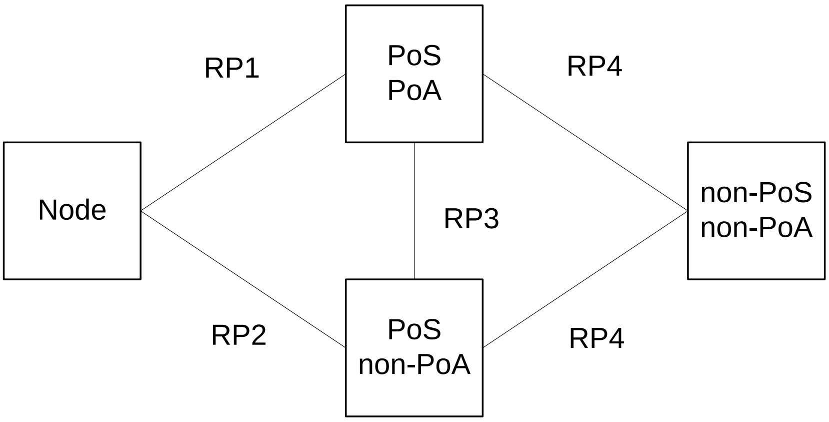

Figure 3: Media Independent Services Layer Reference Model

The reference model also provides four reference points (RP):

- RP1: This reference point is used between N and a PoS, PoA. This is the communication point used by N to contact with its access point or a neighbouring node and encompasses L2 and L3 communication mechanisms.
- RP2: This reference point is used between N and a PoS, non-PoA entity. This communication reference point is used between N and a neighbouring node to which N does not have an association established. This communication point uses L3 communication mechanisms.
- RP3: This reference point is used between a PoS, PoA and a PoS, non-PoA. An example of use would be communicating with a new mesh node via PoS-PoA that already has a connection with this new mesh node. The communication through this reference point can be performed over L2 or L3 mechanisms.
- RP4: This reference point is used to communicate a PoS, PoA or PoS, non-PoA with a non-PoS, non-PoA entities. This is the case of an AP (PoS, PoA) or a neighbouring node to which N wants to connect (PoS, non-PoA) to an Information Server. This communication is performed by L3 mechanisms.

In the case of RP2, there are cases where the nodes are not able to talk directly through L3 communication. As an example consider a node that is not configured and starts its own auto-configuration mechanisms. The node needs to talk at some point with a neighbour, to which it is not connected through L3 since the node still has not acquired the IP address. In this example a new communication mechanism, enabling the node to talk to a neighbour to which there is no direct communication and without using L3 is required. We define this operational mode as Proxy Mode, understanding it as a combination of RP2 and RP3. In Proxy Mode the query is sent to an L2 neighbour (at L2) which acting as a proxy sends the query to the appropriate destination through L3 mechanisms.

4. Conclusions

Currently operators are diversifying their offer in terms of available radio technologies for the Radio Access Network. This imposes a high complexity in the nodes of the

network as they need to handle a variety of technologies. In order to tackle this complexity, the concept of Media Independent Services Layer (MISL) has recently appeared in the IEEE as an abstraction layer providing homogeneous services. A good starting point for the design of the MISL is IEEE 802.21 which is the first specification where the concept of abstraction appears.
The IEEE has already identified the Spectrum Optimization & White Spaces as a scenario requiring the use of an abstraction layer able to handle the heterogeneity of the underlying technologies. This paper presents the requirements of the scenario in terms of functionality to be provided by the future MISL. Furthermore we propose the architectural basis for building the MISL.

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References

[1] "Media Independent Handover Services," IEEE Standard for for Local and Metropolitan Area Networks, 2008.

[2] A. De La Oliva, A. Banchs, I. Soto, T. Melia, and A. Vidal, "An overview of IEEE 802.21: media-independent handover services," *IEEE Wireless Communications*, vol. 15, no. 4, pp. 96–103, 2008.

[3] "IEEE 1900.4: Architectural Building Blocks Enabling Network-Device Distributed Decision Making for Optimized Radio Resource Usage in Heterogeneous Wireless Access Networks," 2009.

[4] R. Prasad, P. Pawlczak, J. Hoffmeyer, and H. Berger, "Cognitive functionality in next generation wireless networks: standardization efforts [cognitive radio communications]," *IEEE Communications Magazine*, vol. 46, no. 4, pp. 72–78, 2008.

[5] "PAR 802.22:Information Technology -Telecommunications and information exchange between systems - Wireless Regional Area Networks (WRAN) - Specific requirements - Part 22: Cognitive Wireless RAN Medium Access Control (MAC) and Physical Layer (PHY) specifications: Policies and procedures for operation in the TV Bands," 2004.

[6] Burak Simsek, Christian Niephaus, Johannes Lessmann, Antonio de la Oliva, "Convergence between 802.21 and SCC41," July 2009.