

OmniRAN Network Reference Model with Backhaul

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Abstract

This contribution reviews the implications of prior contributions with respect to the P802.1CF Network Reference Model (NRM). It recommends expanding the tentative NRM to divide the Access block into individual Access Point and Backhaul elements, with an explicit Access block control element.

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Abstract

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Introduction

Under Project P802.1CF, the 802.1 OmniRAN Task Group is developing a Recommended Practice entitled “Network Reference Model and Functional Description of IEEE 802 Access Network.” Various pictorial representations of the Network Reference Model (NRM), including abstract network entities and reference points, have been discussed in the context of the P802.1CF project and in the prior OmniRAN Study Group. As discussed herein, prior contributions indicate a range of interpretations of the NRM diagram, indicating that significant ambiguities remain in the model. Some contributions have introduced a backhaul network or elucidated such a network separate from access points serving a terminal. Other contributions have suggested splitting reference points to accommodate separated control and data paths.

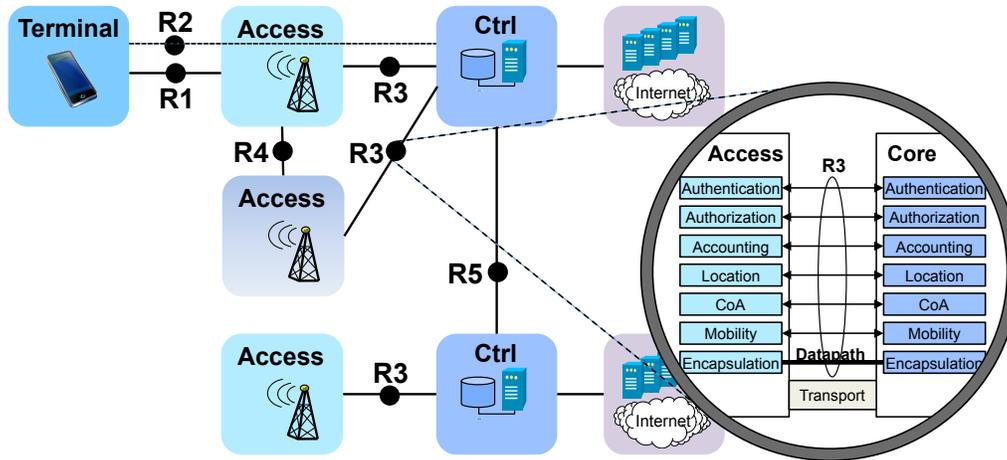
This contribution reviews the NRM and key elements of prior contributions. It proposes a new NRM that divides the Access network into separate backhaul and access point elements while also introducing additional reference points for additional control.

Background

The currently presumed tentative Network Reference Model (NRM) for the P802.1CF specification is incorporated in a number of documents, including omniran-14-0038-00-CF00. It is shown in Fig. 1.

omniran-14-0038-00-CF00

Reference Model for IEEE 802 Network with Reference Points



- Reference Points represent a bundle of functions between peer entities
 - Comprising control functions as well as the data path
- Functions are extensible but based on IEEE 802 specific attributes

Fig. 1: tentative P802.1CF Network Reference Model (NRM) with Reference Points

The exact meaning of the NRM, the blocks therein, and the reference points are not precisely defined in existing OmniRAN documentation. One goal of this contribution is to highlight some ambiguities and propose clarifications and additional detail.

Scope of Access Network

Our focus here is on the “Access” block and the reference point R3 between the Access and “Ctrl” blocks. One question that arises regards the scope of the Access block in the model.

The R1 reference point between the Access and Terminal is rather clearly delineated. It appears safe to presume that the R1 reference point occurs at a radio interface or LAN interface port facing the terminal and that the terminal-facing side of the Access block includes a radio access point or some LAN bridging element facing the terminal; this view is reinforced in Fig. 1 by the radio tower illustration dominating the view of the Access block. In this contribution, we will refer to the terminal-facing elements as access points, regardless of whether or not they operate over radio.

The R3 reference point between the Access and Ctrl is less clearly denoted. The connectivity between Ctrl and Terminal implies a switching network between them, which suggests a

switching network between the Ctrl block and any terminal-facing access point. Details of this switching network are not incorporated in the figure.

In attempting to apply Fig. 1, the following questions arise regarding the nature of the Access block:

- What switching networks and network elements are included within the Access block? Is there an advantage to distinguishing them within the architecture?
- Connectivity from an access point to a core is conventionally known as “backhaul.” Backhaul represents a switching network that is subject to external control and management. How is backhaul included in the representation of Fig. 1?
- Per Fig. 1, “Reference Points represent a bundle of functions between peer entities.” What and where is the Peer Entity in the Access block to which the Ctrl block communicates? Is it reasonable to assign a single Peer Entity for this purpose?
- Is it practical to merge access points and distribution networks into a single Access block, with only R1 and R3 reference points?

Views of Access Block

Various views of the NRM can be ascertained from various contributions as well as documents of the OmniRAN Task Group (TG) and the prior OmniRAN Study Group (SG).

In alternative forms of Fig. 1 (e.g., omniran-13-0018-00-ecsg, omniran-13-0060-00-ecsg and omniran-13-0068-03-ecsg), the center of the three lines at the bottom of Fig. 1 reads “Similar to real network interfaces.” This suggests the notion that the reference points have been chosen to represent interfaces between subsets of the network that might typically be supplied by or deployed by different parties. Specified interfaces at such reference points would be particularly valuable to deployment. In many views of the Access block, real network interfaces exist internally.

Another informative view of the NRM (from omniran-13-0048-04-ecsg, omniran-13-0060-00-ecsg, etc.) is shown in Fig. 2. Here the Access block is labelled as an Access Network block, with an illustration indicating that the Access Network incorporates two types of network element: a distribution switch (perhaps a backhaul network) and a multiplicity of access points. Reference Point R2 is provided to allow the Ctrl block to manage the Terminal block. However, no Reference Points are provided for management of the access points or the distribution switch.

Access Network Abstraction by OmniRAN

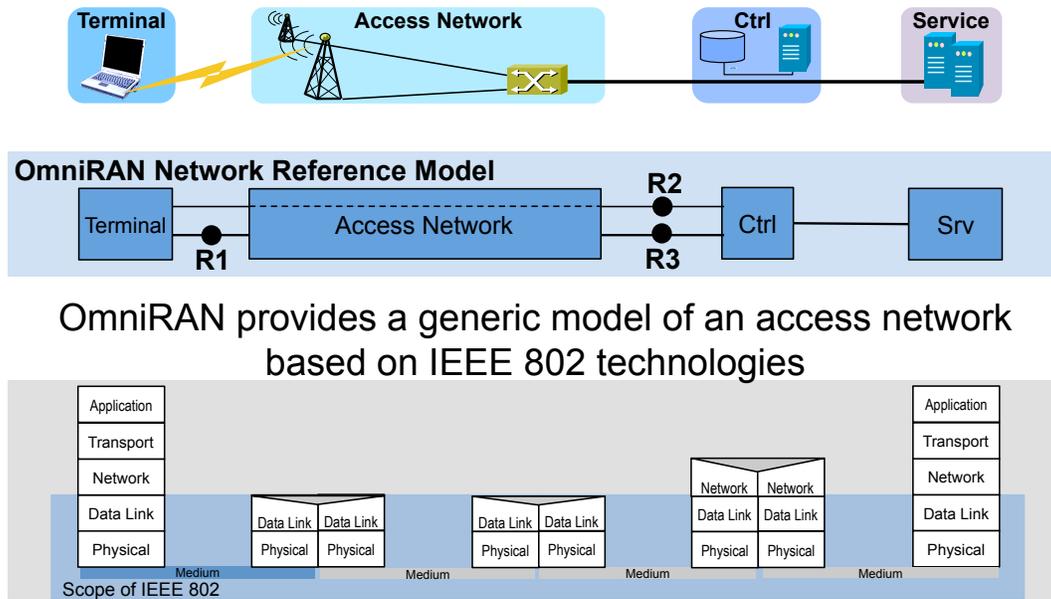


Fig. 2: Access Network Abstraction, per omniran-13-0048-04-ecsg, etc.

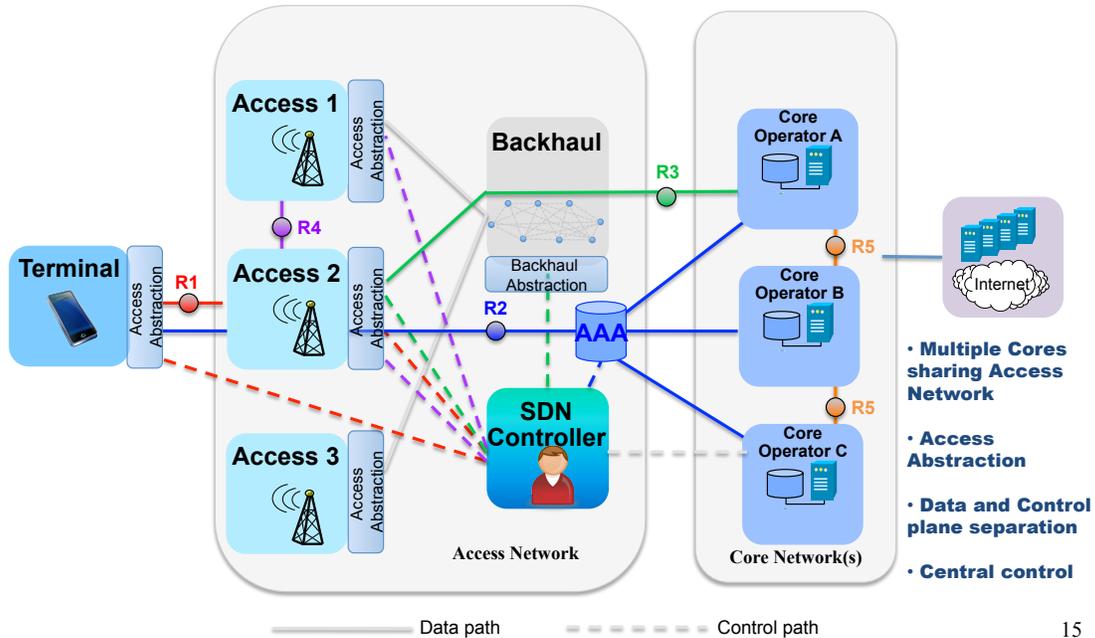
Access Block as Access Points and Backhaul

Various views of the NRM can be ascertained from various contributions as well as OmniRAN TG and SG documents.

In presenting a view of software-defined networking (SDN), Fig. 3 of omniran-13-0060-00-ecsg (from omniran-14-0044-02-0000) illustrates network elements in additional detail in order to demonstrate control of such elements. Accordingly, Fig. 3 introduced a further separation of the Access Network block in terms of sub-blocks Access 1, 2, and 3 (access points, presumably) served through a backhaul network. An SDN controller addresses the access points via an Access Abstraction and addresses the backhaul network via a Backhaul Abstraction. If such control is a significant functionality, one might ask whether and how it should be reflected as reference points.

Furthermore, the very separation into access points and backhaul indicates an interface between the two, as would be expected in implementations. If reference points are “similar to real network interfaces” then perhaps a reference point between the access point and the backhaul should be included.

SDN-based OmniRAN Use Cases Reference Point Mappings



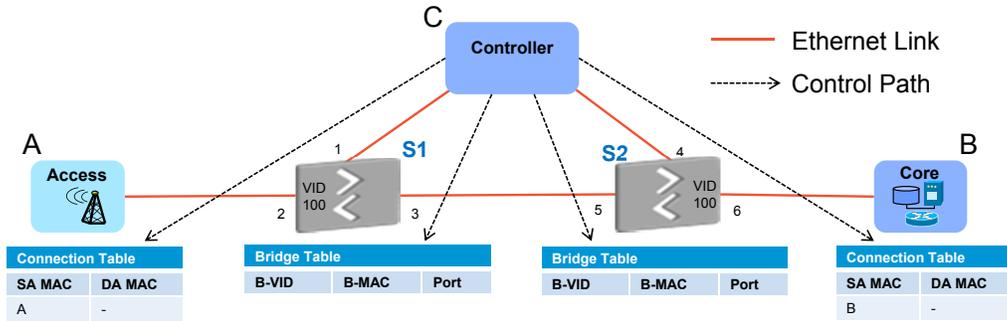
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Fig. 3: Backhaul, per omniran-13-0060-00-ecsg

Backhaul at R3

Other participants interpret Fig. 1 differently. For example, omniran-14-0040-00-CF00 directly addresses the problem of backhaul between access points and “Core” (an earlier label for the Ctrl block, used in earlier documents such as omniran-13-0018-00-ecsg and omniran-13-0060-00-ecsg). This contribution addresses the details of a backhaul network (without using that term). However, rather than understanding the backhaul network to be incorporated into the Access block, it appears to interpret the Access block as representing simply an access point or some other local access network, suggesting that the backhaul is incorporated within the reference point R3. Specifically, it labels a list of technologies as “Some 802.1Q Technologies to Consider for R3,” suggesting that R3 is not only a reference point but also a network. Contribution omniran-14-0040-00-CF00 includes a number of figures (such as that of Fig. 4) illustrating what is, in effect, a backhaul network inserted between the Access and Core (Ctrl) blocks of the NRM.

PB Switches S1 and S2 and SDN Controller C



- S1 and S2 are Provider Bridges configured for PBB-TE forwarding
 - All learning is disabled
 - All frames with unknown addresses are discarded
- C is an SDN controller which will control the configuration of all switches
 - C may use OpenFlow, SNMP, NetConf, etc for its operating protocol



Fig. 4: Access/Core connectivity, per omniran-14-0040-00-CF00

While omniran-13-0060-00-ecsg and omniran-14-0040-00-CF00 interpret the NRM differently, they both recognize the importance of identifying the backhaul and the backhaul control in an understanding of the NRM. Both suggest limitations in Fig. 1.

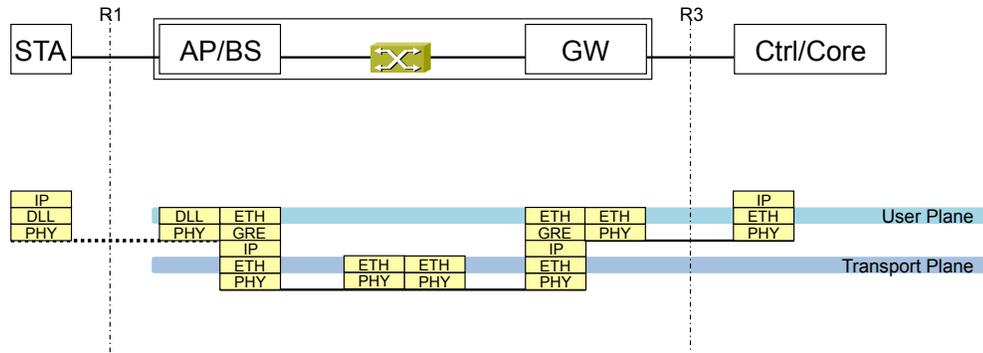
Need for explicit backhaul representation

Contribution omniran-14-0030-00-0000 suggests an approach to resolve the backhaul network problem in the NRM. It proposes that backhaul not be considered as a separate functional entity in the OmniRAN SDN model but instead as part of the access network. It argues that the backhaul construct is a result of a model that incorporates a gateway into the access network (Fig. 5) but that the OmniRAN approach is to flatten the network and do away with the gateway (Fig. 6) so that backhaul can be incorporated as part of the access.

To the extent that “backhaul” is defined as a tunnel, Fig. 6 (with similarities to Fig. 2) does indeed dissolve the backhaul. However, in many contexts, the term “backhaul” is understood more generically. For example, the Small Cell Forum and the Metro Ethernet Forum [9] consider an architecture in which “backhaul” is, generally, the transport network connecting the core network to the access point. This terminology is generally aligned with Fig. 3.

One difficulty raised by Fig. 6 is that eliminating the gateway leads to ambiguity in the meaning of R3. Recall that, per Fig. 1, “Reference Points represent a bundle of functions between peer entities.” When the Ctrl block communicates with an Access Network gateway, then the identity of those peer entities is rather clear. However, when the Ctrl block communicates with an Access Network that is a loosely specified block including some number of switching networks and access points, then the peer entity in the Access Network is difficult to ascertain. As indicated in Fig. 3 and Fig. 4, a number of separate peer entities within the Access Network may need to be controlled.

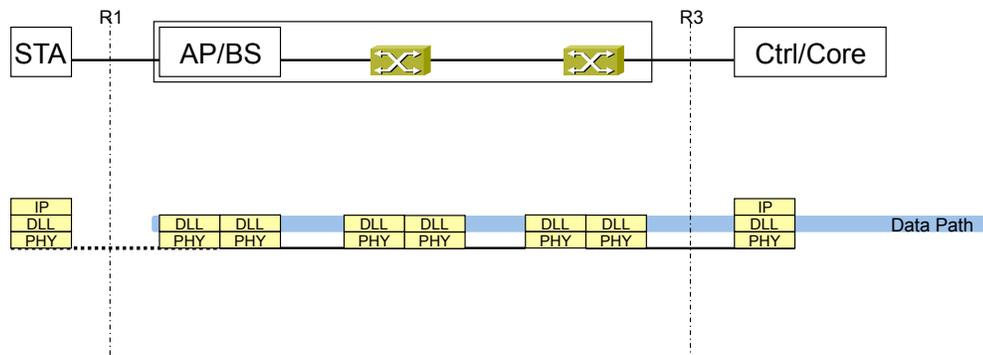
Dedicated Backhaul by Separation of User Plane and Transport Plane



- Separation of user plane and transport plane in the access network leads to the definition of a 'backhaul'

Fig. 5: Backhaul through a gateway, per omniran-14-0030-00-0000

Integrating user plane and transport plane into one networking layer dissolves the 'backhaul'.



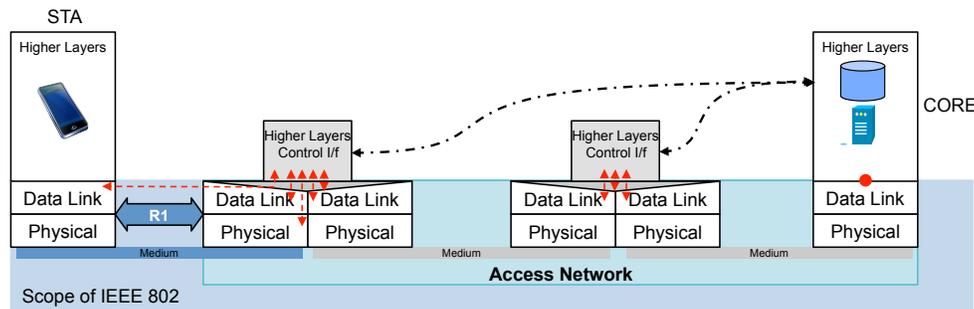
- OmniRAN defines an access network without separation of user plane and transport plane in isolated networking layers. Backhaul can be considered integrated into the data path in OmniRAN.

Fig. 6: OmniRAN, without a gateway, per omniran-14-0030-00-0000

Overloaded R3

Contribution omniran-14-0038-00-CF00 raises the point that R3 is overloaded in that it is presumed to support both control and data, which may follow separate paths in some cases.

Control and Data of R3 may go different paths



- P802.1CF will define an abstraction of an access network based on IEEE 802 technologies
 - The access network provides the link between a station (IP host) and the first hop router
- The abstraction leads to very few generic interfaces for all kind of implementations
 - R1 represents the PHY and MAC layer functions between terminal and base station, which are completely covered by the IEEE 802 specifications
 - R2 represents a control interface between terminal and central control entity, e.g. for authentication
 - R3 represents a control interface between the access network and a central control entity and the data path interface towards the first hop router, which is defined by the IEEE 802 Data Link SAP.

Fig. 7: Control and data path separation, per omniran-14-0038-00-CF00

Contribution omniran-14-0038-00-CF00 addresses the overloading of R3 into control and path plane reference points, with text in Fig. 7 noting that “R3 represents a control interface between the access network and a central control entity and the data path interface towards the first hop router.” The contribution tentatively proposes the separation of R3 into R3-Control and R3-Data, suggesting that other Reference Points, such as R4, could be considered for a similar split. Note that omniran-13-0067-00-0000 likewise proposed to split R3 into R3-M, R3-C, and R3-D (for management, control, and data, respectively) and to split R4 into R4-C and R4-D.

However, as indicated in Fig. 7, even a separate R3-Control reference point is overloaded, since multiple control paths may be required to provide control to multiple entities within the access network. In the figure, one controlled entity is indicated in the position of an access point, while the other is indicated in the position of a backhaul network. In some ways, this corresponds to the general structure of Fig. 3 and Fig. 4 (with the previously noted variety of views as to whether backhaul is incorporated in the Access block or external to it). However, the control structure indicated in Figs. 3, 4, and 7 differs sharply in the location of the control point. In Fig. 3, the SDN control point is inside the Access block. In Fig. 4, the SDN controller is at an unspecified location. However, in Fig. 7, the SDN controller is presumed to lie within the Ctrl block, directly controlling all subnetworks within the Access block. Such a structure presumes that the Core operator may be positioned to be aware of the internals of the entire Access block and best positioned to control it. In many cases, however, the Access block may be controlled by an independent operator that is cognizant of its own internal network and best able to control it, simultaneously managing network flows of many core operators who are unaware of each other’s traffic. Therefore, direct control of the elements of the Access block may be better left to a controller within the Access block. However, in some circumstances, it may also be valuable to support a control messaging path allowing the Core operator to communicate flow and

configuration requirements to the Access block. The Core operator’s need for a direct control link to the Terminal (via R2) are not paralleled by a need for direct control of the Access block network elements.

Network Reference Model with Backhaul

With the preceding considerations in mind, this contribution proposes the modified Network Reference Model of Fig. 8, with the Access block divided into individual Access Point and Backhaul elements, joined at Reference Point R6. R6 supports both data and control, presumed to follow the same path. It is the control element of R6 that most strongly motivates the need to specify that Reference Point. Different IEEE 802 Access Point technologies have different control methods, but an Access Point abstraction, specified through control at R6, would form the basis of a unified interface.

Fig. 8 also introduces a Ctrl element in the Access block, providing direct control of the Backhaul via a control-only Reference Point R7. The Ctrl element is enabled to control the Access Point via the Backhaul, through R6. Alternatively, a direct path could be added to the NRM allowing the Ctrl element to control the Access Point by a separate path.

R3 is divided into two reference points:

- R3d is the Reference Point for data
- R3c is the Reference Point for communications with Ctrl element in the Access block. In some cases, this path may be absent. Otherwise, the control could be strong or weak, depending on the circumstances.

Network Reference Model with Backhaul

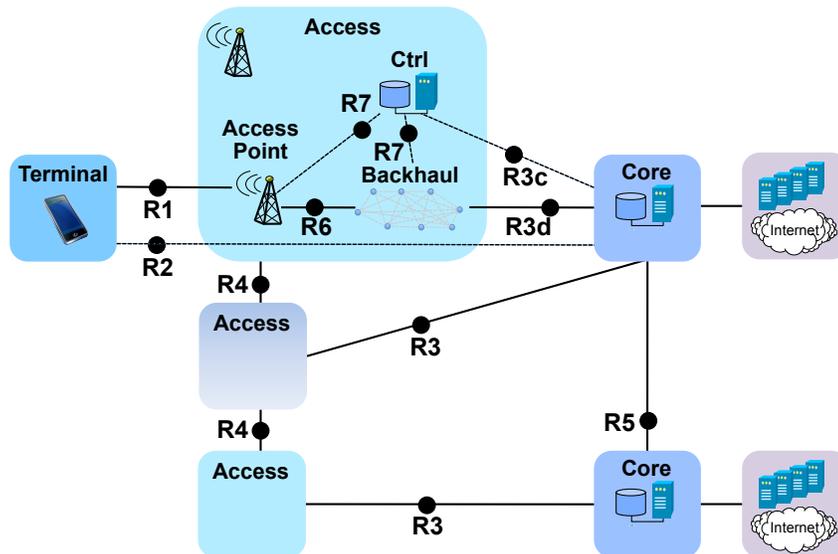


Fig. 8: Network Reference Model with Backhaul, with dotted lines representing control-only links

In Fig. 8, a second Access Point is illustrated within the Access block. This highlights the common backhaul connectivity of the Access Points within an Access block, with the potential for the Access Points to communicate with each other via the Backhaul.

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