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Use Cases and Architecture of Central Controlled IP RAN
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Abstract

This document introduces the requirements and use cases for IP RAN (Radio Access Networks). To support the requirements, the document provides an architecture with centralized control plane as well as separation of control plane and data plane. The document also describes techniques for IP RAN network initialization and construction; interfacing to management plane and third party applications. This document can be used as a guideline for central controlled IP RAN design and development.

Status of This Memo

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1. Introduction

1.1. Requirement Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

1.2. Terminology

The following terms are used in this document:

ASG: Aggregation Service gateway
BS: Base station
BSC: Base station controller
CSG: Cell site gateway
CE: Customer Edge
CP-DP: Control Plane and Data Plane interface
IP RAN: IP Radio Access Network
IP RNC: IP Radio network controller
NMG: Network management
MME: Mobile management entity
MPLS: Multi-protocol Label Switching
RSC: Radio service controller
RSG: Radio Service Gateway
SGW: Serving gateway
SR: Service router

VLAN - Virtual Local Area Network
VPN - Virtual private network

2. Requirements and use case for central controlled IP RAN

2.1. Scenarios of traditional IP RAN

IP RAN is mainly used to carry the traffic from 3G, LTE base station to provide the carrier of high speed service for IP-based mobile back haul.

The normal topology in IP RAN is based on ring or tree. When L3 service is required in metro, aggregation and access area, IP RAN usually uses ring topology to form the network.

Fig. 1 shows a typical network topology of IP RAN. There are two layers: access layer and aggregation layer. The access devices are the edge of the IP RAN, and are used for the service access; The aggregation devices are used to aggregate the traffic from access devices.

The traffic from base station goes via FE/GE to access device. Access device will establish two redundant pseudowires to two aggregation devices. Aggregation device will terminate the pseudowires and get into the L3VPN. Two aggregation devices will work as the gateway for L3 services, and provide the protection for the base station service. The service core network element will access the metro core after the aggregation of CE, and are connected with base station through L3VPN.

```
          |<-Pseudowire->|<---L3VPN--->|

   +---+ +----+   +-------+         +-------+        +-------+
   |BS|--|CSG|----| ASG   |---------| RSG   |--------| BSC   |
   +---+ +----+   +-------+\      / +-------+\----  /+-------+
           |               \     /     |     \   \ /
           |                \   /      |      \   \
   +---+ +----+              \ /       |       \ / \ +--------+
```

```
   |BS|--|CSG|                \        |        \   -|ATM RSC|
   +--+  +----+              / \       |       / \ / +--------+
           |                /   \      |      /   /
           |               /     \     |     /   / \
   +--+  +----+   +-------+/      \ +-------+/---/  \+-------+
   |BS|--|CSG|----| ASG   |---------| RSG   |--------|       |
   +--+  +----+   +-------+         +-------+        +-------+
                                                 IP RNC/S-GW/MME

           |<-access->|<-aggregation-->|


     Fig. 1 Traditional IP RAN Network Structure
```

2.2. Requirements of central controlled IP RAN

IP RAN uses the design ideas from flexible IP network communication, and is based on the architecture of traditional router. It enhances the OAM mechanism, service protection, and the capability of

multiplexing clock transportation. The routing based hardware structure has rich L3 routing functions. It can provide the better multi-service carrier, and support multi-point to multi-point communication scenario in future mobile network. Compared with traditional IP metro network, IP RAN solution will focus on the high availability, simplified operation and management, networking intelligence and OPEX saving from end to end, etc.

The problems in traditional IP RAN network

Network high availability
: IP RAN is based on the traditional IP router platform, it uses complicated IP and MPLS protocols to construct the network with huge amount of devices. This is a challenge to the high availability of network deployment

Complexity of network management
: IP RAN deployment usually involves a lot of IP MPLS devices, this will introduce very complicated issues in network management and operation. In a typical big metro area, for a local network with the scale of 10k base stations, we need to increase the network with 10500 IP/MPLS equipments. The IP

network scale (equipment number) will increase 10 times, and equipment is distributed divergently. This will cause the operation pressure to carriers they nerve faced before. In addition to that, there are many protocols running between access and aggregation devices, network operators must understand and memory lot information regarding to protocols and network structures. It increases the complexity of network operation, and brings more OPEX to carriers.

Low intelligence in network
The time gaps in the mobile network evolving from 2G to 3G and to 4G are decreasing. New value added service and application keep coming up. The question about how to quickly deploy new service and establish the dynamic maintenances will bring in more harsh technical requirements to traditional IP RAN.

Using the architecture of central control, separation of control plane and forwarding plane, open and programmability, we can find out the solution for the network high availability, complexity of operation and management, network intelligence.

2.3. Network structure of central controlled IP RAN

The network structure of central controlled IP RAN is illustrated in Fig. 2 to Fig. 4. The network is still layered as access and aggregation layers. There is central controller to provide the control capability of topology discovery, path calculation and service establishment. There are three modes for central controller, one is built-in controller mode and other two are separated controller mode but for different scope of network. Details for these models and architectures are given in section 3 of the same document.

2.3.1. Mode 1: Built-in Controller

For this mode, the controller is integrated into aggregation routers. There may be multiple controller in a IP RAN.

```
                    *********<-----Built-in Controller Running on ASG
```

```
    +--+   +---+ * +---+ *
    |BS|---|CSG|---|ASG|\*
    +--+   +---+ * +---+ \
             |   *   |   *\
    +--+   +---+ ********* \
    |BS|---|CSG|     |      \
    +--+   +---+     |       \
             |   *********    \
    +--+   +---+ * +---+ *     \ +------+        +------+
    |BS|---|CSG|---|ASG| *      \| RSG |---------| BSC  |
    +--+   +---+ * +---+\*      /+------+\----  /+------+
                 *       \     /    |    \   \ /
                 *********\   /     |     \   \
                           \ /      |      \ / \ +--------+
                            \       |       \   -|ATM RSC|
                           / \      |      / \ / +--------+
                 *********/   \     |     /   /
                 *       /     \    |    /   / \
    +--+   +---+ * +---+/*      \+------+/----  \+------+
    |BS|---|CSG|---|ASG| *      /| RSG |---------|      |
    +--+   +---+ * +---+ *     / +------+        +------+
             |   *   |   *    /               IP RNC/S-GW/MME
    +--+   +---+ *********   /
    |BS|---|CSG|     |      /
    +--+   +---+     |     /
             |   *********/
    +--+   +---+ * +---+ /
    |BS|---|CSG|---|ASG|/*
    +--+   +---+ * +---+ *
                 *       *<-----Built-in Controller Running on ASG
                 *********
```

Fig. 2 IP RAN Mode 1: Built-in Controller running on ASG

2.3.2. Mode 2: Stand-alone Controller for Access and Aggregation

For this mode, the stand-alone central controller is used. The control functions in access and aggregation devices are moved to the controller server named IPRAN-CP in this document. In such a way, the access and aggregation devices are only responsible for the forwarding. The controller can control multiple aggregation and access devices.

```
                                +----------+
                                |          |
        *****************-------| IPRAN-CP |
   +--+ * +---+   +---+ *       |          |
   |BS|---|CSG|---|ASG|\*       +----------+
   +--+ * +---+   +---+ \
        *   |       |   *\
   +--+ * +---+     |   * \
   |BS|---|CSG|     |   *  \
   +--+ * +---+     |   *   \
        *   |       |   *    \
   +--+ * +---+   +---+ *     \ +-----+         +------+
   |BS|---|CSG|---|ASG| *      \| RSG |---------| BSC  |
   +--+ * +---+   +---+\*      /+-----+\----   /+------+
        *               \     /    |    \   \ /
        *               *\   /     |     \   \
        *               * \ /      |      \ / \ +-------+
        *controlled area*  \       |       \   -|ATM RSC|
        *               * / \      |      / \ / +-------+
        *               */   \     |     /   /
        *               /     \    |    /   / \
   +--+ * +---+   +---+/*      \+-----+/----   \+------+
   |BS|---|CSG|---|ASG| *      /| RSG |---------|      |
   +--+ * +---+   +---+ *     / +-----+         +------+
        *   |       |   *    /               IP RNC/S-GW/MME
   +--+ * +---+     |   *   /
   |BS|---|CSG|     |   *  /
   +--+ * +---+     |   * /
        *   |       |   */
   +--+ * +---+   +---+ /
   |BS|---|CSG|---|ASG|/*
   +--+ * +---+   +---+ *
        *               *
        *****************
```

Fig.3 IP RAN Mode 2: Stand-alone Controller Controls CSG and ASG

2.3.3. Mode 3: Stand-alone Controller for Access and Aggregation

For this mode, the stand-alone central controller is used too. The difference from the mode 2 is that the controller will control the access and aggregation layers include RSG. This mode can provide the control capability from end to end.

```
                                                 +----------+
                                                 |          |
        **********************************-------| IPRAN-CP |
   +--+ * +---+   +---+                  *       |          |
   |BS|---|CSG|---|ASG|\                 *       +----------+
   +--+ * +---+   +---+ \                *
        *   |       |    \               *
   +--+ * +---+     |     \              *
   |BS|---|CSG|     |      \             *
   +--+ * +---+     |       \            *
        *   |       |        \           *
   +--+ * +---+   +---+       \ +-----+  *      +------+
   |BS|---|CSG|---|ASG|        \| RSG |---------| BSC  |
   +--+ * +---+   +---+\       /+-----+\----   /+------+
        *               \     /     |     \*  \ /
        *                \   /      |     \   \
        *                 \ /       |     *\ / \ +-------+
        *                  \        |     * \   -|ATM RSC|
        *                 / \       |     */ \ / +-------+
        *                /   \      |     /   /
        *               /     \     |    /*  / \
   +--+ * +---+   +---+/       \+-----+/----   \+------+
   |BS|---|CSG|---|ASG|        /| RSG |---------|      |
   +--+ * +---+   +---+       / +-----+  *      +------+
        *   |       |        /           *   IP RNC/S-GW/MME
   +--+ * +---+     |       /            *
   |BS|---|CSG|     |      /             *
   +--+ * +---+     |     /              *
        *   |       |    /               *
   +--+ * +---+   +---+ /                *
   |BS|---|CSG|---|ASG|/                 *
   +--+ * +---+   +---+                  *
        *       controlled area          *
        **********************************
```

Fig.4 IP RAN Mode 3: Stand-alone Controller controls from CSG to RSG

2.4. Service Carrier Requirement for Central Controlled IP RAN

The central controlled IP RAN must satisfy two major categories of requirements for services. One is for mobile back haul and another one is for enterprises and governments. Services include Ethernet, ATM and TDM.

2.4.1. Requirements for the Carrier of Mobile Backhaul

1 Support the access of IP and Ethernet, provide the high available, high throughput carrier for the traffic of mobile back haul

2 Provide the carrier for LTE network, support the flexible access between base stations, multi-home base station, and the carrier of multicast traffic for base stations

3 Provide the power monitoring, integrated network management for different systems of access services

2.4.2. Requirements for the carrier of enterprises and governments

1 Provide the high available, high throughput carrier for the access of L2/L3 VPN services, it includes P2P, P2MP and MP2MP tunnels

2 Support the access of high bandwidth Internet leased line, circuit emulation, access of ATM/FR/TDM

3. Central Controlled IR RAN Architecture

3.1. Reference Architecture

```
                +----------+           +----------+
                | Third    |           |Network   |
                | Party App|           |Management|
                +----------+           +----------+
                            \         /       |
                             \       /        |
                            +--------+      to NMG interfaces
                            |IPRAN-CP|      on network devices
                            +--------+
                           /   |   |  \
                          /    |   |   \
               ........../.....|...|....\.............
               .  +----+-----+ |   |   +----+-----+  .
     +----+    .  |Base|Cntl | |   |   |Base|Cntl |  .
     | BS |----.--|Rtg |Agent|-|---|---|Rtg |Agent|\ .
     +----+    .  |----------| |   |   |----------| \.
               .  |Frwd Node1| |   |   |Frwd Node2|  \
               .  +----------+ |   |   +----------+  .\
               .               /    \                . \+--------+
               .              /      \               . /|RNC/SGW/|
               .  +----+-----+        +----+-----+   ./ |MME/BSC |
     +----+    .  |Base|Cntl |        |Base|Cntl |   /  +--------+
     | BS |----.---Rtg |Agent|        |Rtg |Agent|  /.
     +----+    .  |----------|        |----------| / .
               .  |Frwd Node1|        |Frwd Node2|/  .
               .  +----------+        +----------+   .
               . Central|Controlled Area   |         .
               .........|..................|..........
                        |                  |
   .....................|..................|...............
     TDM/ATM/Ethernet   |      MPLS        | TDM/ATM/Ethernet
```

Fig 5. Central Controlled IP RAN Architecture

Above is the central controlled IP RAN architecture, where the control plane is separated from the forwarding plane and moved to an independent entity named IPRAN-CP (IP RAN Control Plane) in this document.

IPRAN-CP, IP RAN Control Plane, is a software system that can be

deployed either in a network device or a separate computer server. IPRAN-CP controls the entire IP RAN network domain, the size of the domain can be defined by Network Operator based on the actual network planning and use cases. IPRAN-CP controls the IP RAN network based on the network topology, actual states and status, which are operated by the network administrator.

IPRAN-CP provides northbound interface to network management system used for service deployment, monitoring, troubleshooting, fault location, and other functions. Netconf could be one of the option for northbound interface implementation. The northbound interface of IPRAN-CP is different from the traditional network equipment interfaces. It is based on the network view and virtual interfaces. IPRAN-CP can provide the interface to network topology and operate on a virtual network.

At the same time, IPRAN-CP also opens to third-party application, allows third party to use RESTful API to program and control network devices. Through IPRAN-CP, Third-party applications can utilize the access to network resources (such as network topology), deliver network diagnosis, fault location, application performance monitoring, add innovative applications in the future and so on.

Because the control plane has been separated out, the network devices become forwarding nodes in the IP RAN domain. Forwarding nodes still keep the basic routing functions in order to establish control and management channel between IPRAN-CP/NMG and all the forwarding nodes. Other control functionality is moved to IPRAN-CP, the forwarding node no longer has the control plane functions (such as protocols needed for establishing services). Forwarding node accepts network resources and states from the controller via Control Agent module and reports itself (such as ports) to the controller.

Forwarding nodes still need traditional northbound managemnent interface. However northbound interface features of the network services and the protocol are no longer included. Instead only a small subset of the features such as power supplies, voltages, veneers and other management features are remained on the network devices. The forwarding plane continues to maintain the existing schema using IP/MPLS forwarding.

3.2. Reference Model

According to different use cases and scenarios, typical reference model can be either in built-in model or stand-alone model. Where the stand-alone model can be divided into another two different sub models

3.2.1. Central Controlled IP RAN in Built-in Model

```
              .....................................
              .   +----+-----+                    .
+-----+       .   |Base|Cntl |     +-----------+  .   +----+-----+
| BS  |-I1-----|Rtg |Agent|-I2--|Central-CP|  .   |Base|Cntl |
+-----+       .   |----+-----|     |-----------|----I4-|Rtg |Agent|
              .   |   CSG 1  |-----|   ASG 1   |  .   |----+-----|
              .   +----------+\   /+-----------+  .   |   RSG 1  |
              .                \ /                .   +----------+
              .                 * I3              .
              .                / \                .
              .   +----+-----+/   \+-----------+  .   +----+-----+
+-----+       .   |Base|Cntl |-----|Central-CP|  .   |Base|Cntl |
| BS  |-I1-----|Rtg |Agent|     |-----------|  .   |Rtg |Agnet|
+-----+       .   |----+-----|-I2--|   ASG 2   |---I4--|----+-----|
              .   |   CSG 2  |     +-----------+  .   |   RSG 2  |
              .   +----------+                    .   +----------+
              .                                   .
              .    Central Controlled Domain      .
              .....................................
```

Fig 6. Central Controlled IPRAN in Built-in Model

Like the one above in an IP RAN network, IPRAN-CP functionality is built into aggregation service gateway ASG, in which an ASG controls a group of CSGs connected to it. IPRAN-CP functionality is integrated with ASG that retains its original aggregation features. The original control functionality on CSG is moved up to ASG. The ASG with built-in IPRAN-CP controls the forwarding behavior of CSG. CSG retains basic routing functions for establishing the communication channel with management plane and control plane. CSG communicates with IPRAN-CP through a control agent running on CSG, the agent performs status reporting and accepts control information distributed by the central control plane residing on ASG.

In this reference model, an IP RAN domain can have more than one ASG, every ASG has a built-in IPRAN-CP. A CSG can be controlled by a single or multiple(in ring structure) ASG(s). In case there are two or more ASGs, one ASG works as master controller, and the other one works as alternative backup. IPRAN-CP can also do load-balancing. In case of CSG redundancy, each active and standby can be controlled by different ASG.

IPRAN-DP supports the network virtualization capabilities, internal CSG topology of an IP RAN is not visible to external network. For external routing device, it only establishes routing neighbor with ASG, and believes that only the ASG routes while the CSG routes are invisible. External routing equipment can considered an IPRAN-CP controlled domain is a big virtual router.

Using built-in mode, the one can use the existing network equipment to perform software upgrades, apply the new control technology in the access network. Changes to the network architecture and network management model can be limited to small. It is a good strategy to conduct the rapid deployment of central controlled IP RAN.

3.2.2. Central Controlled IP RAN in Stand-alone Model

Built-in IPRAN-CP is easy of deployment and takes advantage of existing network structure, equipments and other investment. However because there is no separation of control plane and forwarding plane

on the existing device that IPRAN-CP attached to, for example ASG, the control ability, network performance and the domain scope are limited by the capability of the existing aggregation equipment ASG and its attached network structure.

Stand-alone IPRAN-CP model is designed to resolve above issue. It deploys IPRAN-CP with stand-alone computer server(s) or other IT hardware to eliminate the physical limitation of ASG. The stand-alone control server can use the commodity product with much stronger CPU power and process ability. The controller no longer participates in the forwarding of network traffic like ASG does; it can be located in a remote data center without geographical limitation thus it is able to control more and more network nodes in different locations. Therefore stand-alone IPRAN-CP can provide higher scalability and batter performance.


```
                         +---------+
                         |IPRAN-CP |
                         +---------+
                        /I3  |I3|   \I3
                       /     |  |    \
            ........../......|..|.....\...........
            .  +----+-----+  |  |  +----+-----+  .   +----+-----+
    +----+  .  |Base|Cntl |  |  |  |Base|Cntl |  .   |Base|Cntl |
    | BS |-I1--|Rtg |Agent|--|I2|--|Rtg |Agent|---I4-|Rtg |Agent|
    +----+  .  |----------|  |  |  |----------|  .   |----------|
            .  |   CSG 1  |  |  |  |  ASG 1   |  .   |   RSG 1  |
```

```
            .  +----------+  |  |  +----------+  .   +----------+
            .               /    \               .
            .              /      \              .
            .  +----+-----+       +----+-----+   .   +----+-----+
            .  |Base|Cntl |       |Base|Cntl |   .   |Base|Cntl |
    +----+  .  |Rtg |Agent|       |Rtg |Agent|   .   |Rtg |Agent|
    | BS |-I1--|----------|---I2--|----------|---I4--|----------|
    +----+  .  |  CSG 2   |       |  ASG 2   |   .   |   RSG 2  |
            .  +----------+       +----------+   .   +----------+
            .           IP RAN Domain            .
            ......................................

    -------------------------------------------------------------------
                         +---------+
                         | IP RAN  |---------------+
                         |   CP    |               |
                         +---------+------------+  |
                        /I3  |I3|   \I3         |I3|
                       /     |  |    \          |  |
            ........../......|..|.....\.........|..|................
            .  +----+-----+  |  |  +----+-----+ |  | +----+-----+  .
    +----+  .  |Base|Cntl |  |  |  |Base|Cntl | |  +-|Base|Cntl |  .
    | BS |-I1--|Rtg |Agent|--|--|--|Rtg |Agent|-|----|Rtg |Agent|  .
    +----+  .  |----------|  |  |  |----------| |    |----------|  .
            .  |   CSG 1  |  |  |  |  ASG 1   | |    |   RSG 1  |  .
            .  +----------+  |  |  +----------+ |    +----------+  .
            .               /    \              |                  .
            .              /      \             |                  .
            .  +----+-----+        +----+-----+ |    +----+-----+  .
    +----+  .  |Base|Cntl |        |Base|Cntl | +----|Base|Cntl |  .
    | BS |  .  |Rtg |Agent|        |Rtg |Agent|      |Rtg |Agent|  .
    +----|-I1--|----------|---I2---|----------|---I4-|----------|  .
            .  |  CSG 2   |        |  ASG 2   |      |   RSG 2  |  .
            .  +----------+        +----------+      +----------+  .
            .                 IP RAN Domain                        .
            ........................................................
```


Fig 7. Central Controlled IP RAN in Stand-alone Model

Above diagram shows a use case of stand-alone IP RAN control plane. Where IPRAN-CP software is pulled out from ASG and running on a separate computer server (or in a proprietary device, this document follow-up to the server instead). The servers do not participate in the forwarding of network traffic. The network devices to be controlled by IPRAN-CP can be vary depending on the scope of the actual needs. You can only control access layer equipment, or you can also control the devices include both access layer and aggregation layer.

Different from built-in IPRAN-CP on ASG, a stand-alone control plane can control and manage many CSGs as well as ASG itself, or more than one ASGs with CSGs connected to them. If needed, it can also control even RSGs in an extended IP RAN domain. In this use case, CSG, ASG as well as RSG are integrated with a Control Agent module. Control Agent is responsible for reporting topology, states and statistics to IPRAN-CP; and receiving control information and forwarding tables from IPRAN-CP. The network devices include CSG, ASG and RSG keep basic routing functions for establishing control channel and management channel so that IPRAN-CP can use CP-DP (control plane and data plane) protocol to control these devices.

IPRAN-CP needed to support network virtualization functions, from the view of the external network devices, this IPRAN domain is just a single logical router. If any forwarding device (for example CSG) within the domain has communicated with external network nodes using traditional routing protocol such as BGP,IGP,LDP or RSVP, the central controlled IPRAN-CP must support the same communication channel and support the same routing protocols on behalf of the forwarding devices.

3.2.3. Functional Block

This section describes the functions and features to be supported by the control plane and forwarding plane respectively.

The functions of IPRAN-CP:

- o CP-DP control protocol features: provide forwarding device control information; establish and maintain connections between control plane and the forwarding nodes. CP-DP protocol can be XMPP, Openflow, or a newly defined protocol.

- o Network resource management features: discover and collect the forwarding nodes, the ports on the nodes as well as topology resources in the IP RAN domain. Other software modules can use the resource collection to calculate path, deploying services, and build forwarding tables etc. IPRAN-CP should also open to network management applications and third-party applications to programm and manage the network resources.

- o Network virtualization features: abstract network and shield the physical network details from the service layer. Operational service deployment can be done based on virtual network without concernning how forwarding path for the virtual network to get through at the lower layer. In IP RAN, the transport uses MPLS, the network virtualization here means MPLS virtualization.

- o Network protocol layer: provides traditional routers supported conventional routing protocol stack, which was running on the forwarding nodes. Now these features are moved up to the central controller.

- o Network service layer: Supports IP RAN required L2VPN and L3VPN services. L2VPN including VPWS and VPLS.

- o Supporting module: provides basic tools include fault location, alarm, northbound interface for maintenance and management capabilities.

The functions of forwarding node:

- o Basic routing features: run IGP routing protocol and responsible for establishing connectivity with other devices, setup routes and collect topology. It must be done before a controller can communicate with the network devices.

- o Control protocols: corresponds to the control protocol running on the IPRAN-CP device, responsible for establish and maintain CP-DP connection.

- o Control Agent: Responsible for the registration with IPRAN-CP; reporting its information to the controller; accepting control information and forwarding tables distributed by the IPRAN-DP. Control Agent is also responsible to install the forwarding tables to the data plane that is used to guide the traffic forwarding.

- o Forwarding Plane: forwarding and procession of messages and user traffics.

- o Support module: provides debug and diagnostics functions on forwarding nodes; supports device management features; provides interface to network management (include power supplies, voltages, etc).

3.2.4. Interface Definition

The interfaces given on above diagrams (refer to Fig 7) are described at below.

- o I1: Interface between base station and forwarding node. It keeps traditional IP RAN network and base station interface, remains no change.

- o I2: Interface between forwarding nodes.

  * Forwarding nodes run extended ISIS for topology advertisements between nodes. ISIS has been widely used in the existing IP RAN networks to flood link and node information, therefore, ISIS can be leveraged for central controlled IP RAN as part of the topology collection and flood protocol.

  * With built-in model, because IPRAN-CP is running on an existing network devices such ASG, ISIS is running directly between the ASG and the CSG, IPRAN-CP on ASG can get topology information from ISIS directly.

  * With stand-alone model, because SDN IPRAN-CP may be deployed outside of the actual physical network, the control plane cannot communication with forwarding plane via ISIS directly. In this case, a selected topology collection agent in the network will be needed. The agent gathers network topology information from CSGs through ISIS protocol, and then reports the information to IPRAN-CP through a CP-DP protocol. An IP RAN may have very large number of network nodes, while the ability of access equipment is limited. Hence it could be required to divide a IP RAN network into smaller ISIS domains to match the capacity of the access equipment. The topology collection agent usually is located at ASBR node of ISIS such as ASG.

o I3: Interface between IPRAN-CP and forwarding devices. This interface needs to run a CP-DP protocol for the forwarding node's registration, information reporting, and accepting the control information. Options of the CP-DP protocols could be XMPP, OpenFlow or a newly defined protocols. This interface is beyond scope thus left out of this document.

o I4: Interface between IPRAN-CP and external router. It supports conventional routing protocols such as BGP,ISIS,RSVP and LDP etc.

o I5: Interface between RSG and base station controllers. It remains unchanged. (I5 and BSC are not shown on Fig 7 due to space limitation)

3.2.5. Management Plane

IPRAN-CP needs to provide northbound interface used for network management and OSS integration. At the same time, IPRAN-CP needs to provide an open programming interface used for third-party application integration and development. For example, when a third-party monitoring application caught a situation of packet dropping and link quality degradation along a path, they can use programming interfaces of IPRAN-CP to control the path and switch to an alternative path. The northbound interface provided by IPRAN-CP can be divided into the following categories:

o Policy control interface, including routing policy, ACL etc.

o The service interface, including L2VPN,L3VPN etc.

o Path control interface, including control of the forwarding path, switching over, definition of bandwidth constraints etc.

o Monitoring interface, including fault events, network quality threshold, system status monitoring, and statistics etc.

o Resource interfaces, including bandwidth, network topology, tag resources, interface resources etc.

o Diagnostic tools, such as ping, tracert, NQA etc.

Forwarding nodes also have a light network management plane. The management uses VPN channel separated from CP-DP channel to manage the forwarding node. Because forwarding node's control plane has been moved up to IPRAN-CP, therefore management functionality provided by the forwarding nodes, are only themselves the equipment management features as follows:

o Equipment upgrades

o Device management protocols, such as SNMP, Telnet, and FTP etc

o Port management

o Device power, voltage, single-board hardware management features such as alarms, veneer restarts.

o Environmental monitoring of the device, such as temperature alarms etc.

3.2.6. Forwarding Plane

Forwarding IP/MPLS forwarding service.

4. Acknowledgements

We would like to thank Lin Han and Guoyi Chen who provided valuable contribution to this document.

5. IANA Considerations

This draft requires no changes in IANA specification,

6. Security Considerations

This draft does not add any additional security implications to IP RAN networks. All existing authentication and security mechanisms still apply.

7. References

7.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

7.2. Informative References

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