5G RAN optimization using the O-RAN software community’s RIC (RAN Intelligent Controller)

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Thoralf Czichy, Near-RT RIC PTL (thoralf.czichy@nokia.com), https://wiki.o-ran-sc.org/display/RICP
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7. RIC components
ORAN alliance architecture
https://www.o-ran.org/

ORAN software community architecture for near-RT RIC (this slideset just uses "RIC")
What is RIC: architecture and key requirements

RIC Intelligent Controller

- Radio Connection Optimization (xApps)
- RRM optimization (xApps)
- Mobility optimization (xApps)
- Slicing optim. (xApps)
- 3rd party Applications

Container platform (Akraino REC)

Near RT: 10-100ms

Use cases

- Network Intelligence
- Policy Enforcement
- Handover Management
- Radio-Link Management
- Advanced SON
- Load Balancing
- RAN Slicing

- Possibly co-localized with CU
- Managing hundreds of DU’s host 3rd Party apps
- Empowered with AI/ML near-RT capabilities
- Role in network slicing.

- A1: intend based interface (policy)
- E2: interface with base station
- O1: for O&M purpose (FM, PM, CM)

ORAN NGF-1 (Open FH)
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xApps

Example xApps (under O-RAN SC’s RICAPP project)

- **Measurement campaign xApp** - general and procedure-specific KPIs for ~18 EN-DC related messages, using gs-lite stream processing tool
- **Admission control xApp** – uses E2 to play with EN-DC’s SgNBAdditionRequest to implement simple admission control on gNB.
- **kpmion xApp** - collects information from O-CU and O-DU using the E2 interface and calculates KPIs based on this information. Provides information to other xApps
- Proprietary closed-source xApps
- A good way to start getting involved

Generally in areas of

- (from ORAN) Quality of experience (QoE)
- (from ORAN) Traffic steering
- (from ORAN) Massive MIMO, e.g., for customized beam sets
- (from ORAN) RAN slicing
- …
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RICP - Near-RT RIC as a O-RAN SC (Software community) project

• RIC and the O-RAN alliance specifications (in the eight O-RAN working groups) are being developed in parallel. The current RIC platform is build around an experimental E2AP specification proposal that also includes the ASN.1 definitions.

• RIC as project of the ORAN software community (https://o-ran-sc.org/) has formally started in June 2019. Candidate seed code is under https://gerrit.o-ran-sc.org/r/#/admin/projects/ (all under “ric-plt” and under some under “com”) and based on code developed by Nokia and AT&T.

• First formal release will be O-RAN SC’s “Amber” (end of November 2019) with requirements listed in “O-RAN SC Ver A SW Requirements 20190731a” in https://wiki.o-ran-sc.org/display/RSAC/Contributions

• Source code is distributed under the Apache 2 license.

• Simulators are used for development. O-RAN-SC’s O-CU eventually also needs to implement them.
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E2 concepts adapted from O-RAN WG3 E2GAP (General Aspects and Principles)

• **RAN Function definition.** Defines the RAN Function Name and describes the E2 services that the specific RAN Function is currently configured to present over the E2 interface. Typical functions are X2AP, F1AP, E1AP, S1AP, NGAP interfaces and RAN internal functions like UE, cell, node management.

• More detailed E2SM (E2 Service Model) specifications define the function-specific protocols that are implemented on top of the E2 specification.

• In some of RICAPP’s xApps, we use an experimental E2 service model “E2SM for X2AP” for some of the xApps being developed.

• For example, while the E2AP specification proposal defines the concept of event triggers, it is the E2SM for X2AP that defines the specific gNB/eNB-side triggers in the X2AP function based on matching X2AP message type, or X2AP IE.

• **RIC Event Trigger approach.** Describes the approach to be used in RIC Subscription messages to set RIC Event Trigger Definition in the RAN Function. For example, the X2 interface RAN Function may support event triggers for a specific X2 interface (i.e. connected to a specific LTE eNB), for a given interface direction, interface Message type and one or more specific values in one or more nominated IEs (Information Elements).

• **RIC Action Definition approach.** Describes the approach to be used in subsequent RIC Subscription messages to set required sequence of RIC Action in the RAN Function. For example, the X2 interface RAN Function may support INDICATION messages of complete interface message for Report and Insert RIC Services and a particular mechanism to configure one or more POLICY services.

• **RIC Indication header and message approach.** Describes the approach to be used by RAN when composing Indication messages for RIC Report and Insert services. For example, the X2 interface RAN Function uses X2AP based ASN.1 encoding of either whole messages or selected Information Elements

• **RIC Control header and message approach.** Describes the approach to be used by RIC when composing Control messages. For example, the X2 interface RAN Function could use X2AP based ASN.1 encoding of whole messages.

• **RAN Function Policies.** Describes the set of policies that the RAN Function is configured to support and the corresponding parameters that may be used to configure the policy using RIC Policy services.
Many-to-many relationships, but only zero or one RIC per RAN node

The E2 manager is the one that initiates E2 connections with the RAN nodes. It is often referred to as xApp ”zero” – even if it is actually part of the RIC platform. RAN configuration information learned from the RAN during connection establishment (and later RAN Configuration Update procedures) is stored by the RIC E2 manager.

The RAN (gNB/eNB) shall be able to function independently of the RIC and shall maintain normal RAN functionality when and if the E2 interface and/or RIC fails. To this end the E2 interface is functionally an optional interface.
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**Indication-Report**

1. Detect Trigger
2. INDICATION (Subscription, Report)
3. Continue call processing

**Control**

1. Detect EVENT
2. Perform Action
3. CONTROL (Event, State)
4. Resume or Initiate call processing
5. CONTROL ACK

**Policy**

1. Detect Trigger
2. Perform POLICY
3. Continue call processing

**Indication-Insert**

1. Detect Trigger
2. INDICATION (Subscription, UE, Insert)
3. Halt or Suspend call processing
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Expected gNB side of E2 implementation
Example E2 indication report

For example: SgNB Addition Request

- **Event filter:**
  - Triggers on matching events

- **Call flow (Report case):**
  - Event filter always forwards message to event handler
  - If filter matches, event filter forwards to E2 indication handler which then sends it to RIC as Report-Indication
  - xApp(s) in RIC perform analysis
Incoming E2 INDICATION – general flow

1. E2 INDICATION

2. E2 INDICATION
Expected gNB side of E2 implementation

Example E2 policy

For example, SgNB Addition Request

- Event filter:
  - Triggers on matching events

- Call flow (Policy case):
  - Event trigger forwards message to Local Policy
  - Local policy applies rules and either proceeds with original/modified message or replies with SgNB Addition Reject
  - Event handler processes the message as before
E2 SETUP

1. /nodeb/endc-setup (gNB)

2. E2 SETUP REQUEST via RMR

3. SCTP connect

4. E2 SETUP REQUEST (ASN.1)

5. E2 SETUP RESPONSE via RMR

5. E2 SETUP RESPONSE (ASN.1)

6. E2Manager saves the node data in RNIB

RIC

E2 Manager

E2 Termination

Redis RAN RNIB

gNB
xApp E2 Subscription

1. E2 Subscription Request
2. Fetch NB list
3. Send E2 Subscription Request to all NBs
4. Update RMR routes with the new "xApp – subscription" information
5. Update RMR routes with the new "xApp – subscription" information
6. E2 Subscription Ack
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RIC xApp Framework

**xApps**
- Adm Ctrl xApp
- Measurement campaign xApp
- A1 xApp Mediator
- kpimon
- RIC demo xApp (report/control)
- Subscription Manager
- RIC xApp framework
- xApp1
- xApp2
- E2 Manager
- Redis RAN RNIB (e.g., cell data)
- Redis xApp DBs (e.g., UE RNIB)

**Management platform**
- API Gateway (Kong)
- Helm charts
- Image repo

**RIC platform**
- VES Agent / VESPA
- Prometheus
- Logging & OpenTracing
- (Resource Manager)

**RAN, i.e. gNB/eNB**
- E2 Termination

**Akraino REC (Radio Edge Cloud) blueprint**

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# Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>SON</td>
<td>Self organizing networks</td>
</tr>
<tr>
<td>RRH</td>
<td>Remote Radio Head = RU Radio Unit</td>
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<tr>
<td>RNIB</td>
<td>Radio network information base (in RIC)</td>
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<tr>
<td>EPC</td>
<td>Evolved packet core (LTE core)</td>
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<td>gNB</td>
<td>(next) generation node B 5G's base station. Further split into CU (centralized unit) – CU-CP, CU-UP, DU (distributed unit) and RU (e.g. via eCPRI)</td>
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<tr>
<td>eNB</td>
<td>Evolved node B = LTE's base station</td>
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<td>MME</td>
<td>Mobility management entity</td>
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<td>SGW</td>
<td>Serving gateway</td>
</tr>
<tr>
<td>S1-c</td>
<td>EPC’s eNB-to-MME control plane traffic</td>
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<tr>
<td>S1-u</td>
<td>EPC’s eNB-to-SGW user plane traffic</td>
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<td>5G NSA</td>
<td>Non-standalone option 3 &quot;EN DC&quot; (eNB dual connectivity with various submodes for S1-u termination) and suboptions</td>
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<tr>
<td>5G SA</td>
<td>5G standalone architecture</td>
</tr>
<tr>
<td>NR</td>
<td>New radio interface (5G)</td>
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<tr>
<td>NG-RAN (RAN)</td>
<td>Next generation radio (5G)</td>
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<td>5GC</td>
<td>5G core</td>
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<td>PDCP</td>
<td>Packet data convergence protocol (in 5G gNB split architecture typically the lowest layer still on CU)</td>
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<td>SDAP</td>
<td>Service Data Adaptation Protocol (new in 5G)</td>
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<td>ONAP</td>
<td>Open network automation platform</td>
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<tr>
<td>MANO</td>
<td>Management and orchestration</td>
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<td>NMS</td>
<td>Network management system</td>
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<tr>
<td>VESPA</td>
<td>VNF event stream Prometheus Adapter</td>
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<tr>
<td>QoE</td>
<td>Quality of experience</td>
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