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Intelligent ecosystems

How rApp ecosystems drive network optimization, service monetization and user experience

Intelligent Automation Guide Series
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Understanding the role of rApps in RAN automation

Automating operations drives digital transformation, improving user experience and reducing costs. RAN is the largest network component. rApps are key to RAN automation, requiring an intelligent ecosystem enabled by an open platform, a software development toolkit (SDK) and a collaborative environment.

Open RAN architecture describes two new Radio Access Network Intelligent Controller (RIC) entities; the non-real-time RAN intelligent controller (non-RT-RIC) and the near-real-time RAN intelligent controller (near-RT-RIC).

The RIC is essentially an open operating system for hosting automation applications. The non-RT-RIC provides higher layer automation policies with a control loop greater than 1s using automation applications known as rApps. These policies can be implemented through either the near-RT-RIC, with the non-RT-RIC effectively orchestrating the near-RT-RIC, or through direct connection to the RAN nodes using open interfaces – O1, O2 and A1. In existing purpose-built 4G and 5G RAN networks it can connect through proprietary- or vendor-specific interfaces.

The near-RT-RIC provides lower-level or RAN-specific programmatic control of Open RAN open-centralized units (O-CUs) and open-distributed units (O-DUs) using automation applications known as xApps with a control loop of 10ms to 1s.

There is some industry debate about the role of xApps in automating RAN functions. Existing 4G and 5G networks have high automation levels embedded within the RAN and many feel that Open RAN radios should emulate that model instead of requiring a separate application layer to uplift RAN functionality.

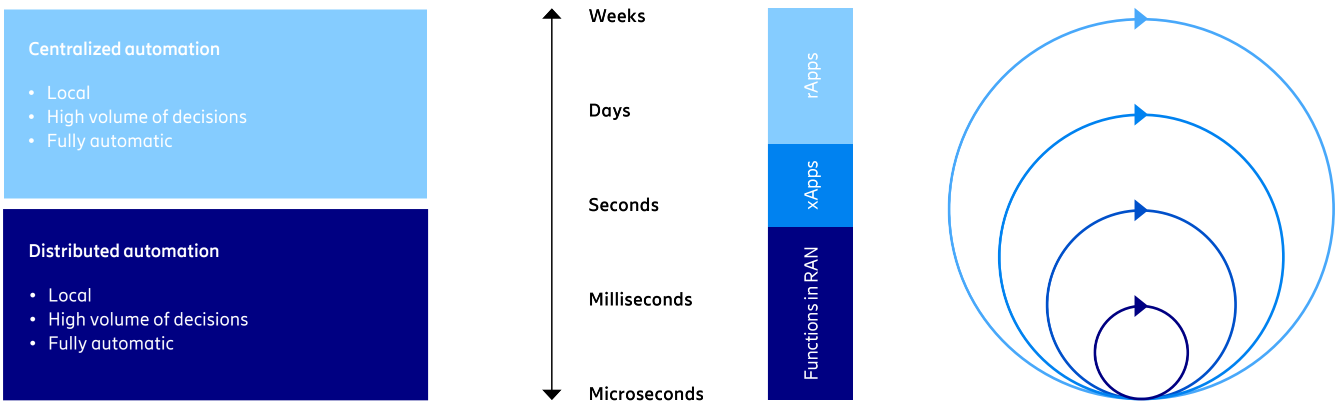
A major difference is that while near-RT-RIC is limited to automation of Open RAN networks only, the non-RT-RIC is seen as an automation platform for multi-vendor, multi-technology networks. Multi-technology networks are the combination of the new Open RAN technologies and purpose-built networks for 4G and 5G mobile technology generations. These purpose-built networks make up around 98 percent of the deployed networks today.

rApps are frequently used in conjunction with artificial intelligence and machine learning (AI and ML) models and can leverage external data sources. This offers a greater opportunity to create new and innovative automation use cases.

There is significant speculation that the entire self-optimizing networks (SON) market will move from its current, tightly integrated architecture to the more open and flexible SON rApps architecture. Service providers could then drive significant platform consolidation within their networks, and the promise of a standardized R1 interface between the SMO/non-RT-RIC and the rApp means that any rApp could work with any R1 interface-compliant SMO, effectively removing vendor lock-in.

Industry analysts, LightCounting, estimate that if every LTE network had centralized-SON (C-SON)– a term that Ericsson believes is more accurately referred to as centralized automation – the global market would exceed USD 8 billion, approximately 8 times greater than today. However, it would also be wrong to conclude that the only use cases for rApps are linked to SON. It appears that there are a number of network planning deployment and sustainability use cases that can be created as rApps.

Figure 1: Understanding RAN automation cycles – RAN functions, xApp and rApps



Understanding the service management and orchestration (SMO) market opportunity

Most industry analysts currently predict that the non-RT-RIC and rApp market will precede implementations of near-RT-RIC and xApps by nearly one year, and that rApps will be the larger market.

LightCounting estimate that by 2026, the SMO market – OSS, orchestration and non-RT-RIC market will exceed USD 1.6 billion per annum.[1] Omdia estimates that the non-RT-RIC and rApps market will exceed USD 350 million per annum.[2]

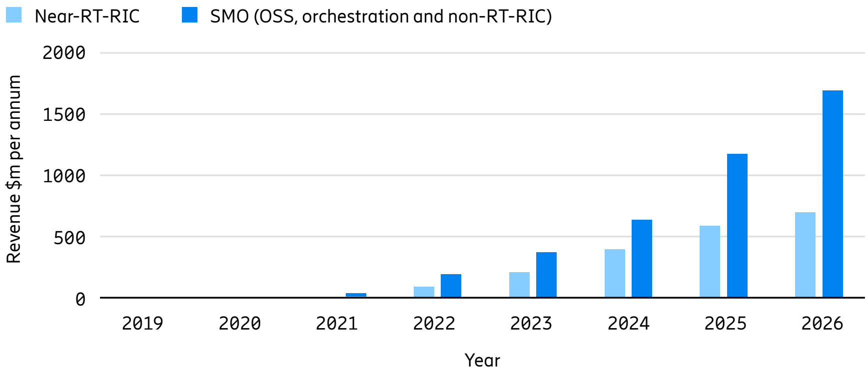
However, recent thinking indicates that some of these figures may underestimate the impact of AI/ML-driven use cases using non-telecoms data sources and the migration of SON to SON rApps on the overall rApp market. In addition, the global increase in energy prices means that the need for energy-saving and sustainability-focused rApps is likely to increase focus and investment.

The role of SMO in RAN automation

Ericsson Intelligent Automation Platform is an Open RAN SMO entity for automation of multi-vendor, multi-technology networks. The Intelligent Automation Platform includes a non-RT RAN intelligent controller, SDK and an open R1 interface to support automation applications – or rApps – from either Ericsson, service providers or other third parties. Ericsson believes that the Intelligent Automation Platform should be a platform for open innovation.

Figure 2: Analyst estimates for the SMO, non-RT-RIC and rApp market vary

LightCounting near-RT-RIC vs. SMO software and service sales



Omdia – RAN intelligent control market estimate

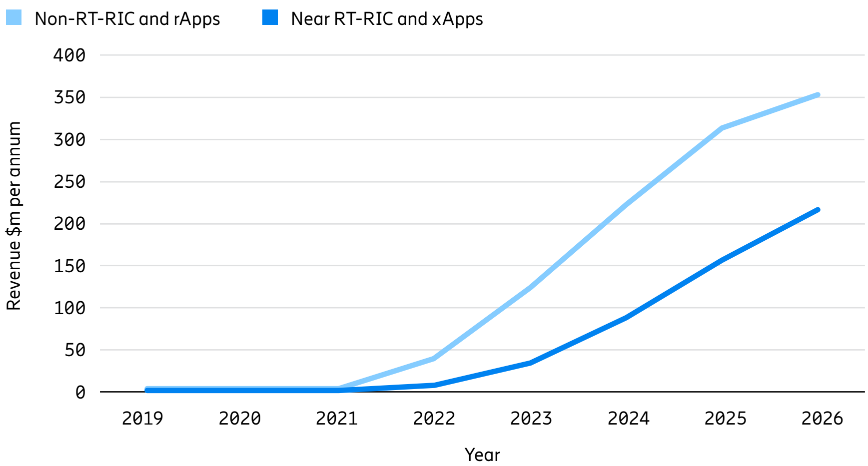
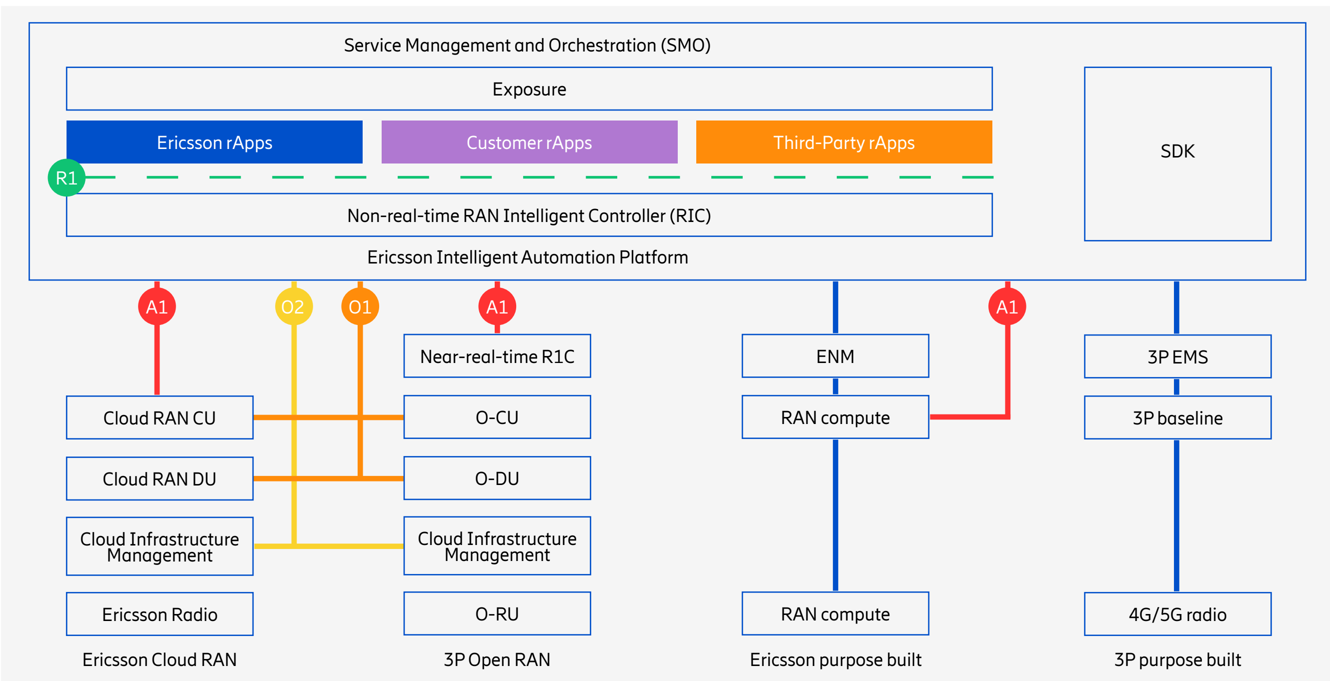


Figure 3: Key components of the Ericsson Intelligent Automation Platform SMO architecture for multi-technology, multi-vendor RAN



[1] LightCounting RAN automation webinar – Nov 2021
[2] Omdia – Self-organizing networks and RAN intelligent control analysis – Dec 2021

Accelerating rApp development

Software applications with intelligence and domain expertise embedded are key to addressing the need for automation in network operations. In many cases today though, the automation platform and applications are tightly paired, meaning that the platform vendor is also the application vendor. This creates lock-in and reduces vendor diversity.

As each software vendor provides their own platform to execute the automation use cases, service providers have previously had to deploy and maintain several software platforms that serve different use cases coming from different providers. These various platforms bring additional complexity to the automation environment for service providers, increasing operational costs and causing inefficiencies when it comes to data storage and processing, for example. Swapping application vendors becomes a long and costly task because it involves replacing not only the application, but also the platform.

The SMO provides a standardized platform for automation applications, or rApps. There is a need to evaluate all existing software applications (use cases) and an aim to transform them into SMO rApps.

Cloud automation and centralized automation applications are expected to be the early use cases for transformation to rApps with other AI/ML-based automation, slicing and edge orchestration use cases to follow.

In the RAN domain today, LTE, LTE-Advanced (4G) and 5G networks continue to be built on proprietary platforms with embedded distributed automation and the option to install a centralized-automation system that acts as an orchestrator located at the Operational Support Systems (OSS) level which monitors the entire RAN. Centralized automation acts as a non-real-time RIC that leverages the distributed automation features embedded in the central unit (CU).

rApp categorization and classification

Ericsson defines four main rApp categories which run on the underlying SMO/non-RT-RIC, forming the AI and automation foundation for all rApps:

- network evolution
- network deployment
- network optimization
- network healing

Typically, the network optimization and healing rApps could be classified as SON rApps. Network evolution would include capacity planning application rApps designed to visualize the future shape of the network and impact of new technologies on performance and experience. Network deployment rApps address areas of planning and deployment such as automated neighbor relations (ANR).

Initial rApps go beyond self-optimizing networks

Ericsson has launched a number of rApps in both the network deployment and network optimization categories alongside its SMO. Just as importantly, Ericsson is building an ecosystem of third-party application developers including global leaders in network optimization and location services, who are already developing rApps leveraging their external data sources and areas of expertise. The following are some examples of early-stage rApps.

Ericsson Frequency Layer Management (FLM) rApp

Ericsson Frequency Layer Manager rApp is an automation application which originates from Ericsson's centralized automation portfolio. It helps improve the user experience by balancing traffic between different frequency layers. Using a hybrid SON approach, FLM applies its centrally built context to tune distributed-automation parameters to achieve the optimization goal of enhanced user experience and improved spectral efficiency.

FLM uses intent-based optimization – a functionality unique to Ericsson in the market – to translate high-level performance goals into actions and targets of network KPIs.

To illustrate this, FLM uses context, such as coverage balance or coverage contiguity measures. This determines the number of users and traffic that can be moved to another cell without impacting the overall performance of the network. Through this, a service-provider-defined strategy to push traffic to a given type of cell can be met.

By applying advanced AI techniques, FLM achieves automated scenario configuration by providing optimal user experience: increased throughput and decreased latency as it meets the traffic and steering criteria defined by the user.

Performance assurance (KPI monitoring with auto-revert) is also implemented in FLM, which ensures that the automated function will not implement changes that degrade the network performance or revert any change that had caused a degradation.

FLM works either in a closed-loop automation, continuously and without user intervention, or in open loop.

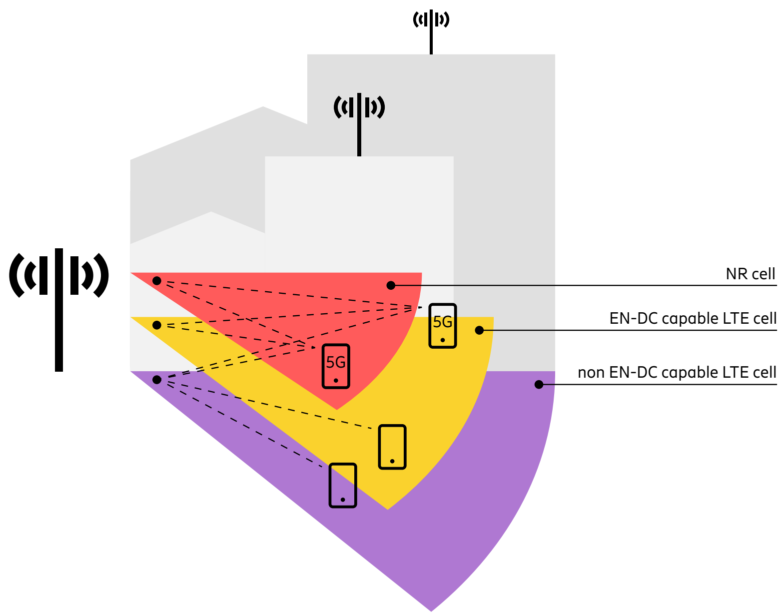
Until 2023, some pre-standard deployments may take place, comprising early use cases, proof-of-concepts and commercial trials. An example is telco cloud for virtualized RAN, C-SON rApps.[3]

[3] Source: Analysys Mason: SMO/NRT RIC forecast for North America (for Ericsson)

Figure 4a: Features and benefits of Ericsson Frequency Layer manager rApp

5G aware Detects ESS/ excludes detect ENDC UEs/excludes at threshold	**Reliability** Assesses reliability of data input for driver KPIs/excludes unreliable cells
Transient Detects transience in driver KPIs/ excludes	**Performance assurance** Monitors key KPIs for degradation/reverts change where degradation detected

Figure 4b: The Ericsson Frequency Layer Manager rApp journey



Ericsson Network Performance Diagnostics rApp
Performance Diagnostics is an AI-powered application that identifies and drills down into the performance issues of 4G and 5G RAN, enabling faster and more effective network optimization activities. With the traditional approach, engineers previously needed to observe and analyze multiple KPIs to find a root cause.

Ericsson 5G Centralized Neighbor Relations rApp
The goal of automatic neighbor relation is to detect new neighbors based on measurements coming from user equipment (UE), create neighbor relations (NRs) and carry all the relevant managed objects (MOs) between the source and the target cells.

These NRs can be utilized for use cases like handover, carrier aggregation, or E-UTRAN-NR dual connectivity (commonly known as ENDC) – a type of transmission where the UE receives information from both LTE and 5G simultaneously. Traditionally, automatic neighbor relation is considered a distributed automation feature running on the RAN node.

Examples of third-party rApps:
Planet rApp

- Infovista's Planet is an AI/ML-powered network planning rApp. It allows service providers to automate network planning activities and enhances capabilities such as site auto-commissioning and automated workflows, which require planning information and/or algorithms.
- Planet provides a highly scalable, cloud-based application for radio frequency planning automation. Planet integrates with external data sources, such as network operations workflows using simplified open APIs to support greater interoperability.

VIAVI – NITRO Mobility rApp

- VIAVI's AI/ML-driven NITRO Mobility rApp captures, locates and analyzes all mobile events across the RF, RAN, xHaul and core, providing service providers with insights to optimize the customer experience and drive new revenue streams.

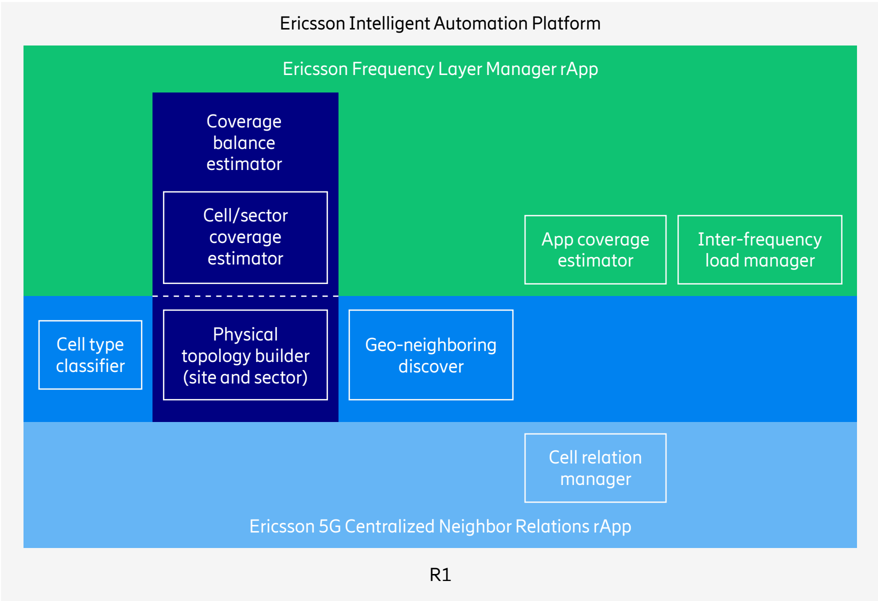
rApp development toolkits and ecosystems
Ericsson believes that there are three stages in developing an rApp ecosystem:

Stage 1: Developer resources enable rapid creation, testing and deployment of rApps including the management of bugs, updates and developments. The best platform vendors will provide a comprehensive SDK.

Stage 2: The developer community connects rApp and platform developers, enabling information to be shared. Ericsson expects leading vendors to provide technical support, testing and certification, as well as collaboration environments for development.

Stage 3: Mass market adoption is where we will see highly developed and mature ecosystems of application developers. Delivery and life cycle management (LCM) will be fully integrated with the service provider's continuous integration/ continuous delivery (CI/CD) pipeline to standardize software asset management. Some organizations believe there will be a common marketplace that provides a catalogue of rApps enabling simpler monetization. However, as rApps and xApps are focused on network automation in a specific telco domain, any potential marketplaces for applications are unlikely to match the scale of consumer marketplaces such as the Apple App Store or Google Play Store for the smartphone industry.

Figure 5: rApp hierarchies showing multiple small rApps creating a larger, more complex rApp



Example: Frequency Layer Manager (FLM)
The FLM rApp is composed of several smaller functions that provide the load balance recommendations. Some of these functions are also shared with other C-SON algorithms, such as automated neighbor relations (ANR), cell type classifier and physical topology builder.

rApp hierarchies
At Ericsson, we envision a hierarchical ecosystem of rApps, with some serving as building blocks, or components, for creating advanced automation functions with a higher degree of complexity. Sharing and reusing components in various algorithms has multiple benefits:

- These building blocks provide a platform-as-a-service (PaaS) capability by enabling rapid application development.
- By creating modular rApps focused on small, specific functionality, an ecosystem is created that is easier to manage.
- This approach will influence platform development and influence standardization.
- It enables existing applications that provide immediate value such as business logic, policies and ML models to become rApps in time.

Each automation rApp can also interwork with other rApps by means of standardized interfaces to build a more complex automation function, in which the insights from one rApp serve as input to another to make more complex decisions. Smaller rApps compose larger use cases.

The importance of an open ecosystem in rApp development
Open RAN envisions openness and the app ecosystem paradigm as being key to stimulating innovation. xApps running on a near-RT-RIC are expected to be open to a limited number of vendors with specific radio expertise because of their limited focus on radio resource management and stringent closed-loop requirements (10ms–1sec). This is further limited by the small number of vendors that have the deep radio expertise required for xApps.

Ericsson believes that rApps will become the key focus for the open ecosystem due to ease of creation, the large number of potential applications and the ability to utilize new external data sources to innovate.

Because of the wider scope of SMO (radio resource control, policy, network slicing, FM/PM and assurance), and variety of RAN data sources (location, FCAPS, policy, SLAs) there is a wider choice for rApp developers than xApp developers.

Ericsson expects that the existing C-SON market will provide the earliest rApps and believes that an rApps ecosystem on top of SMO would foster faster innovation and create a win-win scenario for both SMO vendors, application developers and service providers.

Critical success factors for an rApp ecosystem
There are a small number of factors that are essential for an effective and successful rApp ecosystem:

1. Open knowledge base – ensure a careful selection of open-source technologies and data sources for the SMO SDK/APIs.
2. Partner diversity – select partners that can leverage a wide variety of RAN and external data to create many monetizable rApps.
3. Process – create a scalable process for onboarding and certifying application developers on the SMO platform.
4. Monetization – create an attractive business model and GTM for application developers.

The importance of SDKs in stimulating rApp development

Software development kits, or SDKs, can unlock the power of automation but must be built on a solid foundation of industry experience. That is exactly what the Ericsson Intelligent Automation Platform SDK delivers.

Platform SDKs are much bigger than a set of APIs for development and integration. SDKs need to provide developers with everything required to build and take the application through the different stages in the most effective way, from development to production.

Built on a solid foundation of services, the platform is cloud native (deployed on Kubernetes) and provides a defined architecture, making it easy to understand how applications can be structured. In addition, standard interfaces to integrate with logging, authentication, certificate management and data movement, for example, allow developers to focus on the business logic and deliver the key value of the use case.

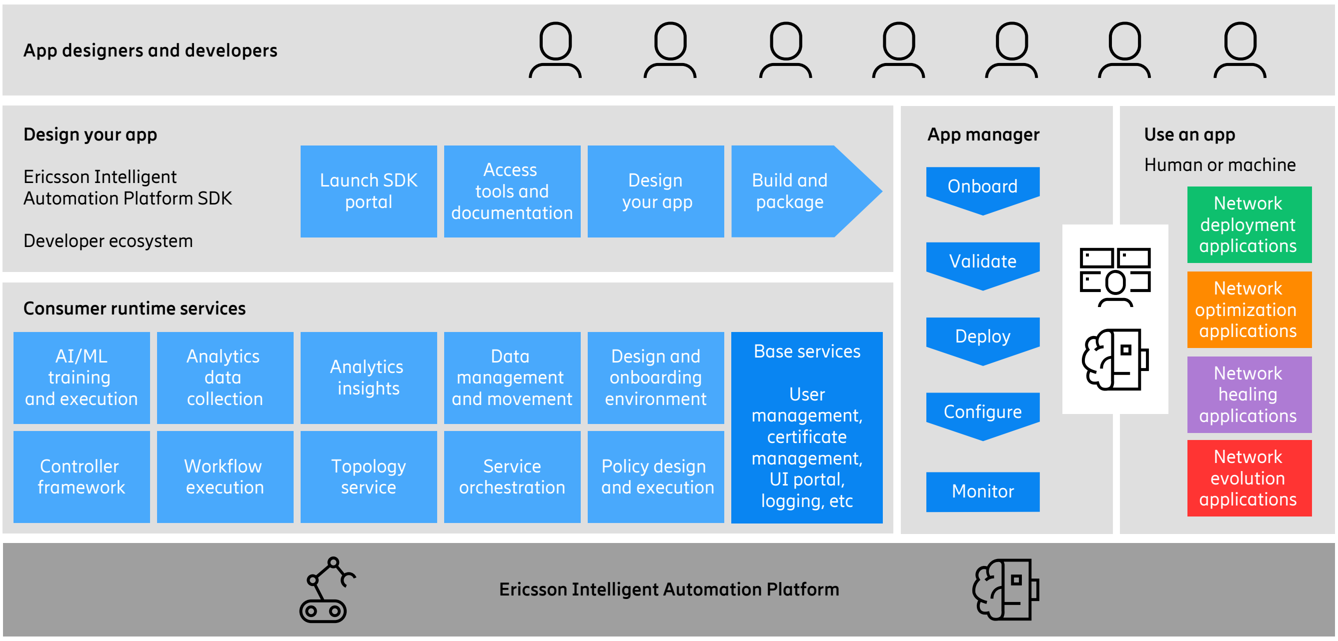
With some industry standards still under definition, the platform is taking a leading approach in pushing forward these interfaces based on the reuse of open-source components. With Ericsson's extensive industry knowledge, we are driving key use cases on the platform, ensuring the APIs are industry-grade. Developers who are experienced in cloud-native development, including microservices, can reuse the industry-standard information along with Open RAN knowledge to push the boundaries of automation.

The design of the platform allows new developers to be onboarded with ease by providing:

- documentation for all exposed APIs
- examples for each API – both parameters that can be sent and examples of data returned
- tutorials and 'how-to' guides for key API services that will underpin most applications
- an example application (microservices-based) that takes the user through the full process of creating an application, along with accompanying documentation with best practices built in
- build utilities that enable packaging of applications for delivery to a runtime system
- an environment to ensure smooth verification of an application prior to publishing
- integration with a CI/CD toolchain
- helper libraries and modules in one or more programming languages to simplify the connectivity to, utilization and debugging of the exposed platform APIs and services

A powerful, feature-rich SDK is key to driving rApp innovation. It lowers the entry barriers for those new to the market, enables faster rApp development and ultimately enables better monetization of the rApp.

Figure 6: Intelligent Automation Platform SDK overview



rApp development routes

The intelligent rApp ecosystem envisaged by Ericsson has multiple development routes. rApps can be divided into four development areas:

- **Simple rApps** – simple automation use cases such as inter-frequency load management or cell/sector coverage estimation.
- **Complex rApps** – these are more complex use cases, potentially utilizing multiple simple rApps to build a complex automation capability such as FLM or ANR.
- **Customer specific** – these are automation cases that apply to a specific customer offering or external environmental factor that is unique or uncommon within the marketplace. These might be areas where a service provider decides to focus on to differentiate their offering from their direct competitors.
- **Generic** – generic rApps are those that support the most common or frequently occurring use cases. The expectation is that these rApps have mass-market appeal and may be deployed by large numbers of service providers.

Typically, different groups will develop different rApps. The expectation is that the SMO and RAN vendors, such as Ericsson, will focus on the more complex rApps but those which also have broad market appeal.

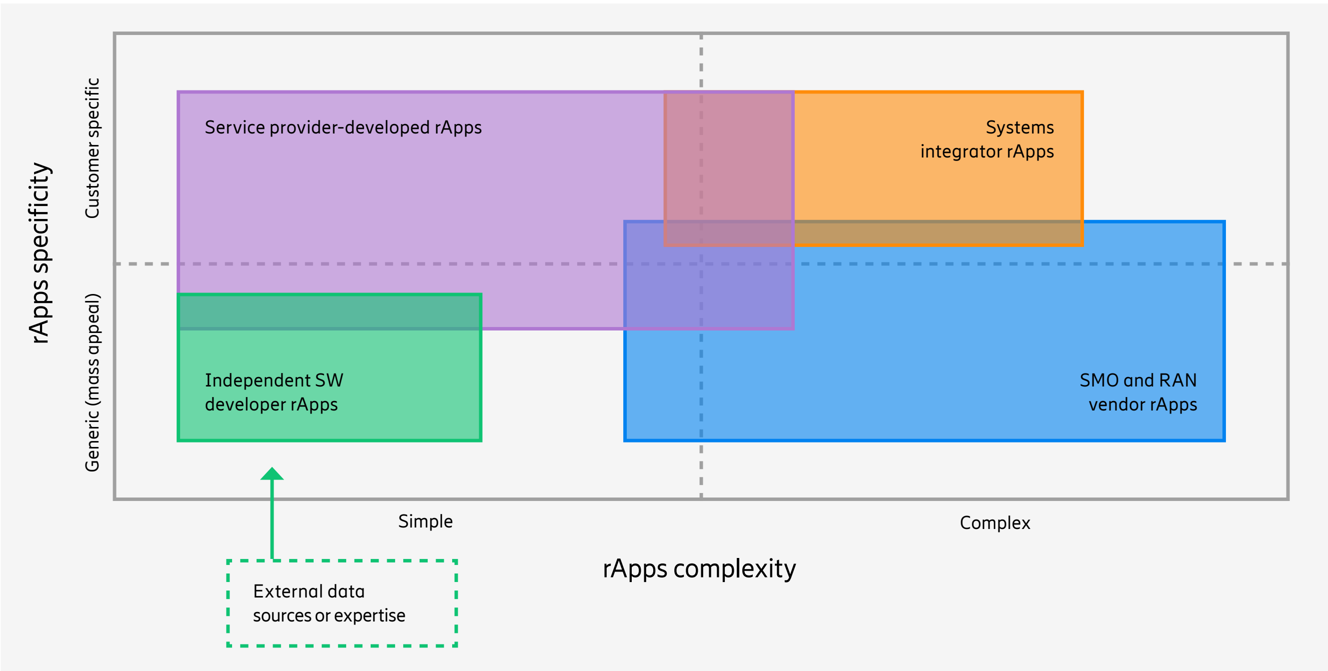
Part of the appeal of the SMO/non-RT-RIC/rApp architecture is the ability for service providers to create automation use cases quickly and easily that relate to their own markets or circumstances. The ability to develop your own rApps is a way for service providers to further differentiate their offering in the home market. Service providers may even commercialize these developments by making them available to other service providers outside their home market, effectively creating a new revenue stream by monetizing their rApp development investment.

The expectation is that service providers will typically focus on the simpler customization use cases, but there are also a number of highly innovative service providers who have the resources, knowledge and experience to create highly complex rApps and are expected to do so.

For more complex but customer-specific rApps, the expectation is that service providers will commission leading systems integrators to develop the rApps on their behalf. However, there may also be some complex hybrid development models associated with rApp development that will relate to IPR and project control.

The final group of rApp developers are arguably the most diverse and interesting. These are independent software developers, some of whom will be new to the telecoms industry. The expectation is that these companies will bring specific, detailed knowledge and data sources which, when combined with existing service provider data, will enable some very powerful and innovative rApp use cases. The appeal for the third-party app developers is the ability to create mass-market rApps that can be monetized across multiple markets. Many of these rApp use cases will be driven by AI/ML models and data sources.

Figure 7: The rApp developer ecosystem – expected approach to rApp development based on complexity and specificity



Conclusion: Stimulating the rApp development ecosystem

For the rApp ecosystem to be commercially successful, it requires a low barrier to entry, particularly for new entrants to the market. It goes without saying that rApps need powerful open-SMO/non-RT-RIC platforms to run on. While simply having open interfaces, such as the O-RAN Alliance R1, is essential, it is highly desirable to move beyond interface specification to standardization which will further improve interoperability.

Independent software developers have the best opportunity for monetization, where their rApps are not locked to a particular vendor's SMO through proprietary interfaces or extensions.

Ericsson believe that the rApp ecosystems are currently at Stage 1 (developer resources). The provision of key developer resources such as SDKs, the ability to provide testing and certification, and detailed technical expertise are all that are required to initiate the rApp developer ecosystem. RAN vendors, service providers, systems integrators and a small number of specialist software developers will be able to build and deploy the early mass-market rApps required to prove the market.

The creation of Stage 2 (developer communities), supported by comprehensive partner programs that provide technical and commercial support, will further stimulate the intelligent ecosystem. The creation of developer communities and sponsored partner programs will industrialize the existing onboarding, testing and certification processes used by early adopters.

Stage 3 (marketplace) is the final stage of rApp development stimulation. While many organizations see a clear need for a neutral, global rApp marketplace, no organization has taken on the responsibility of creating one. SMO and RAN vendors are global, but not neutral. Service providers are typically neutral outside their home markets but don't see rApps as their core business. Systems integrators have neutrality, but the creation of a marketplace doesn't naturally fit with their normal business models.

Many industry observers talk about the concept of an xApp and rApp marketplace similar to the Apple App Store or Google Play Store. At a predicted USD 900 million per annum, the RAN automation application market is large, but is it large enough to sustain a global marketplace?

Regardless of these issues, a number of rApps will deliver a very strong return on investment. Particularly with the current energy crisis, energy-saving rApps are likely to be hugely attractive to service providers whose networks consume vast quantities of power. It may be that the current energy crisis will accelerate the adoption of rApps, but only time will tell.

References and further reading

1. Source: LightCounting RAN automation webinar – Nov 2021
2. Source: Omdia – Self-organizing networks and RAN intelligent control analysis – Dec 2021
3. Source: Analysys Mason: SMO/NRT RIC forecast for North America (for Ericsson)
4. Source: Mobile Experts xApp and rApp market estimates for 2026
5. Ericsson White Paper – Nov 2021 - An intelligent platform: The use of O-RAN's SMO as the enabler for openness and innovation in the RAN domain

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