

O-RAN NETWORK ENERGY MANAGEMENT

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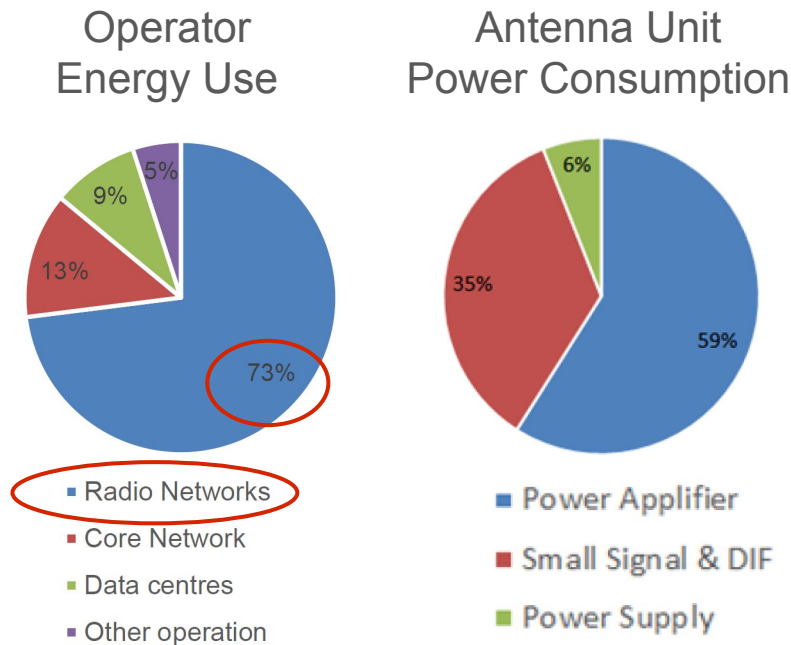
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WINLAB SUMMER INTERNSHIP 2026

OPEN HOUSE PRESENTATION

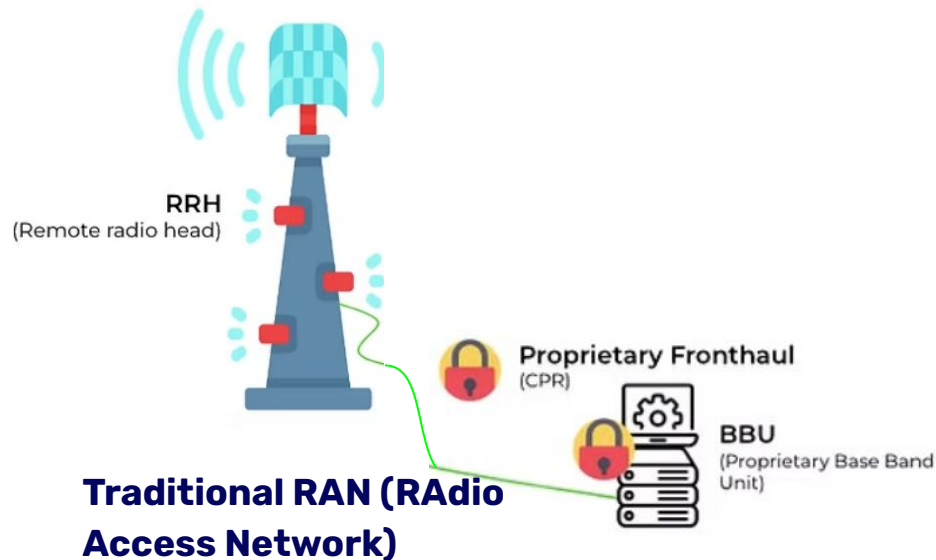
Project Objectives

- Implement the June 2026 O-RAN/OSC Energy Saving Demonstration at WINLAB using open-source **K3s Kubernetes**.
- **Improve O-RAN energy efficiency** by enhancing management of **O-RU M-Plane energy-saving features**
- **Motivation:** The radio network is dominant source (~70%) of mobile network power consumption

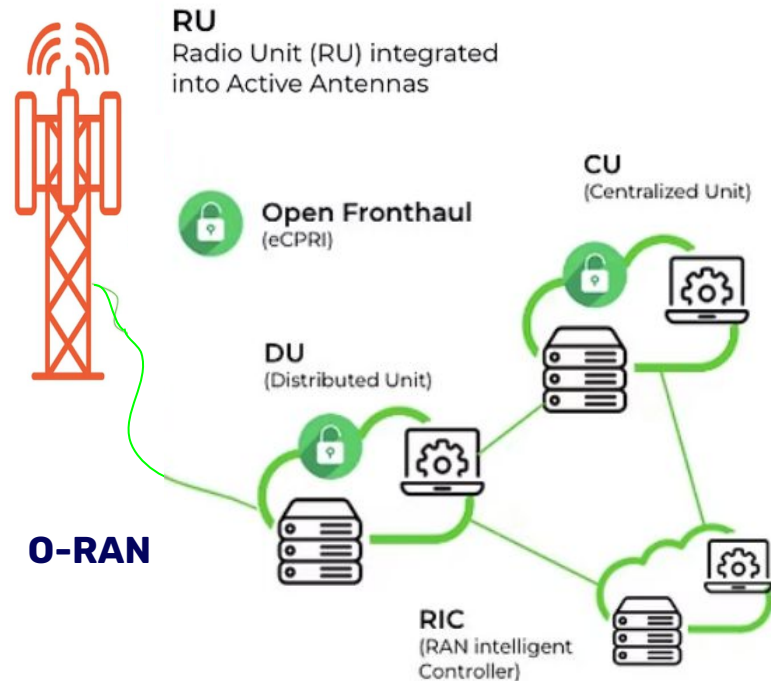


Source: NGMN Alliance, "Green Future Networks – Network Energy Efficiency v1.1," December 2021

Evolution from Traditional RAN to O-RAN



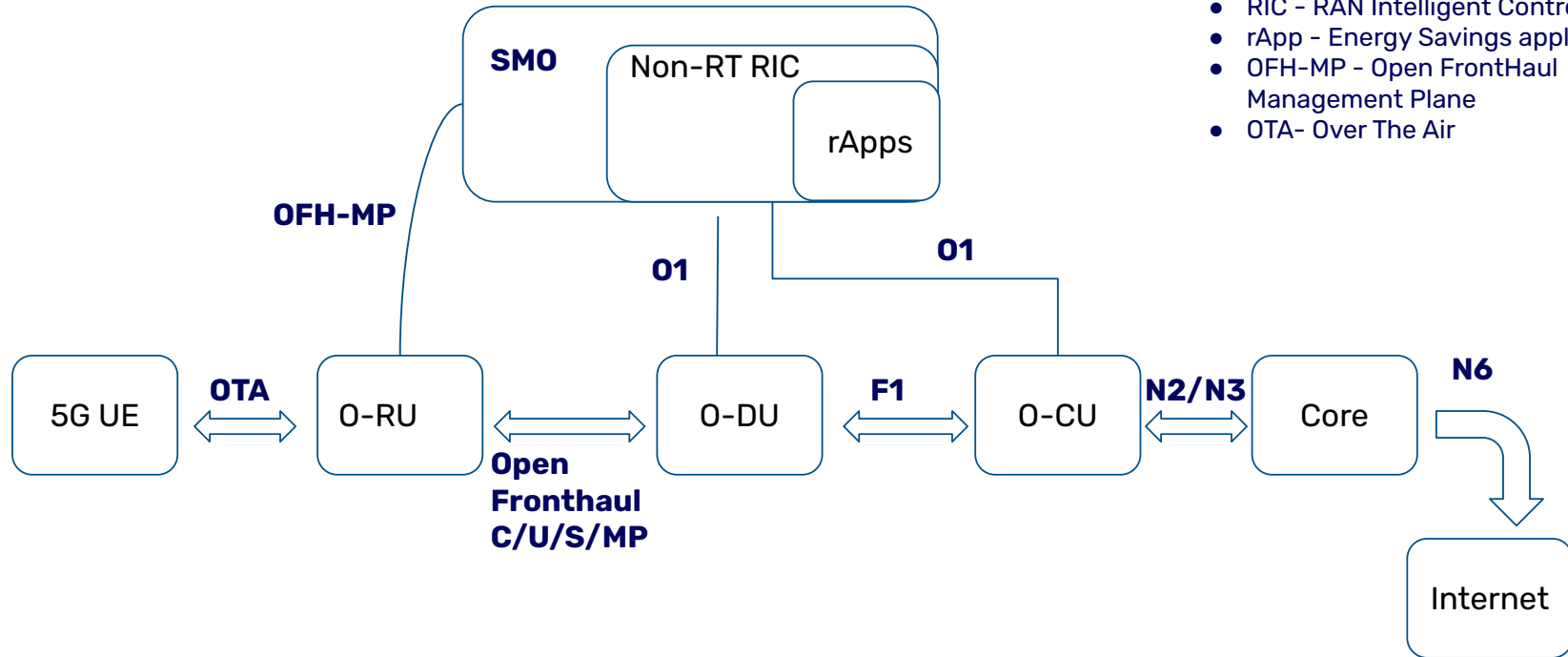
- **Monolithic** architecture
- **Proprietary** interfaces
- **Vendor lock-in**



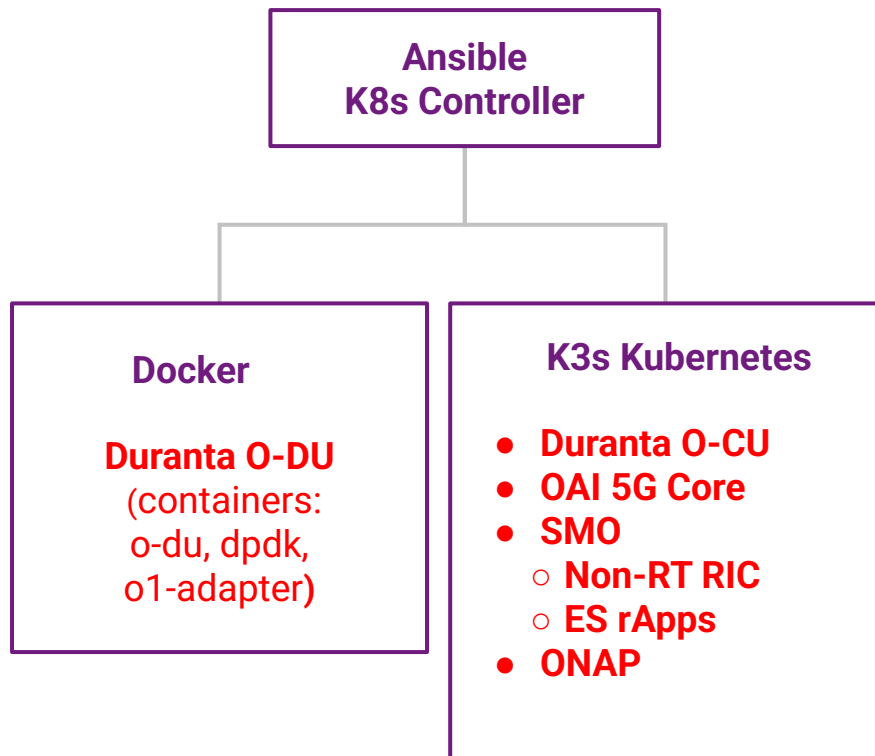
- **Disaggregated** architecture
- **Open** standardized interfaces
- **Multi-vendor** interoperability

O-RAN Components

- UE - User Equipment
- RU- Radio Unit
- DU-Distributed Unit
- CU-Central Unit
- SMO-Service Management and Orchestration
 - RIC - RAN Intelligent Controller
 - rApp - Energy Savings application
- OFH-MP - Open Fronthaul Management Plane
- OTA- Over The Air



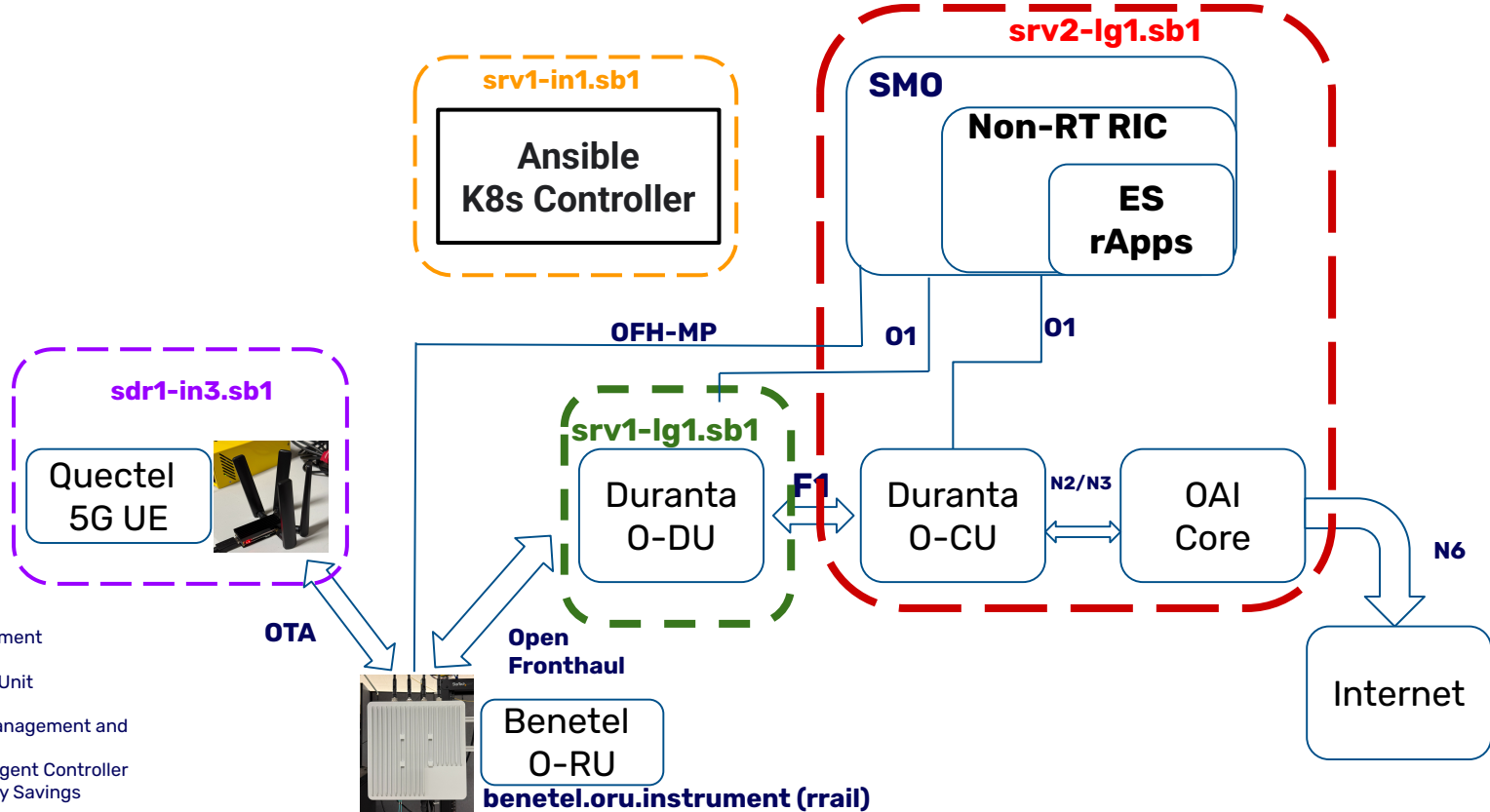
Cloud Deployment Strategy for O-RAN



Deployment Tools:

- **Ansible**
 - Automated deployment and configuration
- **Docker**
 - O-DU containerization
- **Open-source K3s Kubernetes**
 - Container orchestration
- **OpenAirInterface (OAI)**
 - Open-source 5G software stack
- **Duranta**
 - Linux Foundation Open-source O-RAN CU/DU project based on OAI
- **ONAP** - Open Network Automation Platform

WINLAB Sandbox 1 (SB1) Deployment Architecture



- UE - User Equipment
- RU- Radio Unit
- DU-Distributed Unit
- CU-Central Unit
- SMO-Service Management and Orchestration
- RIC - RAN Intelligent Controller
- ES rApp - Energy Savings application
- OFH-MP - Open Fronthaul Management Plane
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Kubernetes Deployment

- Deployed an **open-source K3s** Kubernetes cluster.
- Configured the **K3s controller** and **worker node**.
- Deployed **Duranta O-CU, OAI 5G Core, SMO, Non-RT RIC, ES rApps, and ONAP**.
- Configured **Multus CNI, local-path StorageClass**, and updated **Strimzi** for **K3s compatibility**

Kubernetes Pod Status

oai-core	ims-69779cdb87-4jk7d	1/1	Running	0	3h1m	
oai-core	oai-amf-74d56868c-99nsc	1/1	Running	0	103m	
oai-core	oai-ausf-754b4d6d-glvrz	1/1	Running	0	103m	
oai-core	oai-core-mysql-678bdbfcc7-54bpz	1/1	Running	0	108m	
oai-core	oai-lmf-6b75f4d64d-bnz55	1/1	Running	0	3h1m	
oai-core	oai-nrf-5dd56f4d74-h55qk	1/1	Running	0	3h1m	
oai-core	oai-smf-7458c57b47-g5pzw	1/1	Running	0	3h1m	
oai-core	oai-traffic-server-854d8fc4d7-z5skg	1/1	Running	0	3h1m	
oai-core	oai-udm-85d7ff45d5-tqznd	1/1	Running	0	103m	
oai-core	oai-udr-76f89b64cd-lq65j	1/1	Running	0	103m	
oai-core	oai-upf-7949fd79c5-wjmq9	1/1	Running	0	3h1m	
oai-gnb	oai-cu-65f6ccd474-7kp7c	1/1	Running	0	172m	
nonrttric	rappmanager-0	1/1	Running	0	175m	
nonrttric	servicemanager-7848c84648-mqt7f	1/1	Running	0	3h1m	
nonrttric	topology-5dcff58cb6-gdqfh	1/1	Running	0	3h1m	
onap	onap-policy-clamp-ac-a1pms-ppnt-fb85574f5-bkkqd	1/1	Running	0	3h1m	
onap	onap-policy-clamp-ac-http-ppnt-6fc9f887fd-lqk92	1/1	Running	0	3h1m	
onap	onap-policy-clamp-ac-k8s-ppnt-786dfcfff9-nmj4g	1/1	Running	0	3h1m	
smo	kafka-producer-pm-json2influx-0	1/1	Running	0	175m	
smo	kafka-producer-pm-json2kafka-0	1/1	Running	0	175m	
smo	kafka-producer-pm-xml2json-0	1/1	Running	0	175m	
smo	keycloak-599dc866f9-9x8sp	1/1	Running	0	3h1m	

→ OAI core & OAI CU

→ Non-RT RIC & ES rApps

→ ONAP

→ SMO

All Kubernetes services are successfully deployed and validated

Duranta O-DU Deployment

- Deployed the Duranta O-DU, O1 Adapter and DPDK init containers using **Docker**.
- Configured **DPDK**, HugePages, NUMA, VFIO, and PTP synchronization to support real-time Open Fronthaul communication.
- Successfully established **Open Fronthaul, O1** and **F1** connectivity.

UE Integration

- Updated the OAI 5G Core with the Quectel RM520N-GL subscriber configuration.
- Successfully established **UE registration** and **PDU session**.

gNBs' Information				
Index	Status	Global Id	gNB Name	PLMN
1	Connected	0x0E00	oai-cu	001,01

UEs' Information							
Index	5GMM State	IMSI	GUTI	RAN UE NGAP ID	AMF UE NGAP ID	PLMN	Cell Id
1	5GMM-REGISTERED	001010000000032	00101010041178261634	0x01	0x06	001,01	0000e0001

→ Successful UE registration verified at AMF

O-RAN Software Community (OSC) Open Source Contribution:

- This project is a part of a cutting-edge industry/university open-source collaboration in wireless networking
- Enhanced the June 2026 Energy Savings deployment using open-source K3s Kubernetes integration and platform-specific adaptations, and contributed enhancements to the **O-RAN Software Community (OSC)**.
- Prepared **Detailed Documentation**: [SB1 O-RAN Deployment Progress - Google Docs](#)

Future Work:

- Validate end-to-end user-plane connectivity.
- Enhance and validate **O-RU M-Plane energy-saving** features.