Open AI Cellular (OAIC)
Prototyping AI-Enabled Control and Testing Systems for Cellular Communications

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Provide an open platform (including, software architecture, library and toolset) for prototyping and testing artificial intelligence-based radio access network (RAN) controllers enabling Next-G networks.
Open AI Cellular (OAIC)

- Open AI-enabled Cellular RAN Controllers (OAIC-C)
- Open AI-enabled Cellular RAN Testing (OAIC-T)
Open AI Cellular RAN Controllers (OAIC-C)

OAIC-C => O-RAN Architecture\(^1\) + 5G NR Protocol\(^2\) + Software Radios\(^3\)

**O-RAN component** | **OAIC implementation**
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0-CU, 0-DU, 0-RU | srsRAN-5G with USRPs, new/enhanced interfaces
E2 interface | O-RAN Software Community (OSC)
RAN Intelligent Controller (RIC) | OSC + real time RIC extension
xApps | Existing and new
5G Core | Open5GS

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\(^1\)O-RAN Alliance + New Extensions

\(^2\)Open-source software

\(^3\)Commercial off-the-shelf hardware

Open AI Cellular (OAIC) - An NSF CISE Community Infrastructure Project
**OAIC-C: AI Controllers**

**Existing xApps**
1. Hello World - O-RAN Software Community
2. Bouncer - O-RAN Software Community
3. KPIMON - O-RAN Software Community
4. Traffic Steering - O-RAN Software Community
5. Load Prediction - O-RAN Software Community
6. NexRAN (RAN Slicing) - POWDER

**New xApps (To be released soon)**
1. Age of Information (AoI) Scheduler
2. AI-enabled Schedulers
3. RAN Slicing v2
4. Several xApps (under initial phase)

**Beyond xApps**
- **zApps/dApps**: Real-time control loop for AI-enhanced PHY layer control
- **Orchestration & Management (O&M) and rApps**

Open AI Cellular (OAIC) - An NSF CISE Community Infrastructure Project
Open AI Cellular RAN Testing (OAIC-T)

OAIC-T Server
- Test Case Interpreter
- OAIC-T Engine
- Report Generation

OAIC-T Actor (s)
- Software
  - Actor Manager
  - AI Core
  - Test Executor

Testing signal
Socket
Feedback

Server
<table>
<thead>
<tr>
<th>Test Script Interpreter</th>
<th>Read test scripts in .xml, .json, etc.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Server Engine</td>
<td>Manage all actors, set up testing environment, and monitor test status.</td>
</tr>
<tr>
<td>Report Generation</td>
<td>Generate testing reports and access test repository.</td>
</tr>
</tbody>
</table>

Actor(s)
| Actor Manager           | Manage actor resources and running of test scripts. |
| AI Core                 | Provide AI capability, i.e., AI learner instances. |
| Test Executor           | Execute individual test actions defined in test script. |
| SIM/SDR Adapter         | Provide interfaces to the unit under test. |

Open AI Cellular (OAIC) - An NSF CISE Community Infrastructure Project
Small/Medium-Scale Testbeds

**In-lab Testbed**
- Small-scale in-lab 5G O-RAN testbed at VT, MSU and GMU.
- Features near-RT RIC, 5G NSA and SA, developed using srsRAN and O-RAN software, and 2-14 SDRs and ZeroMQ simulator integrated with GNU Radio.

**Virginia Tech Cognitive Radio Network (CORNET) Testbed**
- Remotely accessible in-building testbed with numerous (nearly 50) USRPs, switches, and virtual machines for development and testing.
- Develop source code, automate testing, deploy applications.
- Users can run sample OAIC experiments or develop and execute new experiments on CORNET.

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Large-Scale Testbeds

CCI xG Testbed

- Large-scale 72-node indoor testbed featuring USRPs and MEC capabilities.
- In collaboration with CCI xG Testbed Director, OAIC will be integrated and made available to testbed users

NSF PAWR Platform

- City-scale outdoor testbeds featuring USRPs and other radios, drones (AERPAW), networking and computing resources, FCC licenses
- In collaboration with PAWR PIs, OAIC will be installed and tested on PAWR platforms and made available to their users

Open AI Cellular (OAIC) - An NSF CISE Community Infrastructure Project
OAIC (both OAIC-C and OAIC-T) will a a **fully open-source community research infrastructure**

- **Source code** will be be made available via Github and/or OAIC website
- **OAIC SDR testbed** will be remotely accessible via website and/or terminal

**How Do I Benefit?**

**Use OAIC-C to build** your own **AI controllers** (using near-RT RIC and/or RT RIC) for PHY, MAC (and possibly higher layers) RAN functionalities

**Use OAIC-T to test** your AI-controlled RAN functionalities. (*Source code will be made available as well.*)

**All the collected dataset** will be made available. You can **remotely** utilize OAIC platform to collect your own dataset for experimental/verification purposes.

**All the documentation, services, tools** will be made available. **OAIC platform** will be also be **remotely** available.
OAIC Timeline and Roadmap

Open AI Cellular (OAIC) - An NSF CISE Community Infrastructure Project
OAIC 1.0: Code

Link: [https://github.com/openaicellular](https://github.com/openaicellular)

Currently supports **O-RAN-based 5G NSA networks**
- Based on srsRAN and OSC code
- Both ZeroMQ Simulator and SDRs
- Upgrade to O-RAN based 5G SA networks *(Will be integrated shortly)*.

Prototyping Next Generation O-RAN Research Testbeds with SDRs

Integrating the Near-Real Time RIC, E2 Interface, and Open-Source Cellular Software

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OAIC 1.0: Documentation

Link: https://openaicellular.github.io/oaic/

YouTube Channel: OAIC
https://www.youtube.com/channel/UCpp9hpRisjMP2gwR5OGEmVQ
Website:

- Existing link: https://sites.google.com/msstate.edu/oaic
- New link: www.openaicellular.org (Will be available shortly)

Mailing list: openaicellular@gmail.com

YouTube channel: OAIC

- Link: https://www.youtube.com/channel/UCpp9hpRisjMP2qwR5OGEmVQ
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Broader Impact

Open AI Cellular (OAIC) - An NSF CISE Community Infrastructure Project
OAIC Team

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Open AI Cellular (OAIC) - An NSF CISE Community Infrastructure Project
Getting Involved

Use, explore and contribute to OAIC community infrastructure project.

- We seek industry involvement with building our OAIC community infrastructure, both OAIC-C and OAIC-T.
- We also want to hear your research interests, discuss collaboration opportunities, define R&D directions and joint projects.

Please reach out to us if you are interested in getting involved with OAIC project

- Email: vshah22@gmu.edu, openaicellular@gmail.com (feel free to get in touch other OAIC PIs/Co-PIs.)
- Follow OAIC website for recent updates
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Backup: AI Challenges in Next-G

While there is lots of optimism in the wireless research community on AI, the reality is that

- There needs to be **sufficient real-world experience at scale** to prove the added expense of AI is justified in improved performance.
- AI in the network needs to be **extensively tested** with the rigor that other elements of the network are tested today.

Some key research questions

- How do we design cellular networks to be more AI suitable at various locations?
- What methodologies apply to test AI performance at various locations in the network?
- How do we test for cross-layer interactions of AI deployed at various points in the network?
- Can testing of AI be used to find configuration failures as well as to ensure secure configurations?
O-RAN Architecture

- **Non-real time RIC**: enables non-real-time control and optimization of RAN elements and resources, AI/ML workflow over A1 interface.
- **Near real time RIC**: control and optimization of O-RAN elements and resources via fine-grained data collection and actions over E2 interface.
- **O-DU**: hosts RLC/MAC/PHY layers
- **O-CU-CP**: hosts the RRC and the control plane part of the PDCP protocol.
- **O-CU-UP**: hosts the user plane part of the PDCP protocol and the SDAP protocol.
- **xApp**: Independent software plug-in to the Near-RT RIC platform to provide functional extensibility to the RAN by third parties

**Control loop timescales**:
- Non-real time: \( > 100 \text{ ms} \)
- Near-real time: \(10\text{ ms} – 1000\text{ ms} \)
- Real time: \(< 1\text{ ms} \)

**Based on two core principles**
- **Openness**
- **Intelligence**

**Flexibility by design**
- Open interfaces and APIs

**3GPP Split 7-2x**
- RAN Intelligent Controllers (RICs)
  - Abstract the networks
  - Allow telecom operators to implement custom control logic