Leveraging an Ecosystem of 5G services
What is LL-MEC?

A Low Latency Multi-access Edge Computing Platform for Software-Defined Mobile Network
A bullet list of LL-MEC objectives:

- Abstraction layer between RAN and CN data plane and LL-MEC platform
- Monitor and control the traffic in the network
- IP-service endpoint and real-time RAN information on per user/service basis
- Low latency applications policies for data plan setup based on traffic statistics
LL-MEC features

- **CN Control and Data plane separation (SDN-based MEC)**
  - Leveraging OpenVirtualSwitch with GTP support and OpenFlow protocol (v1.3)
  - Verticalization of core network at network edge
  - Shared and dedicated core network

- **Abstraction and Programmability**
  - Flexibility and programmability to the underlying RAN and CN data plane
    - Abstraction of underlying data paths with OpenFlow APIs
    - Traffic rules are automatically generated and passed to the associated OpenVirtualSwitch

- **Application SDK**
  - Flexible application programming framework
  - Network abstraction via well-defined northbound interfaces
LL-MEC schema

- **Application manager (mp1)**
  - Low-latency: Core-API
  - Elastic: Rest-API

- **Platform (mp2)**
  - Edge packet service
    - Multi OF libs, OVS
    - Static and dynamic rules
  - Radio network information
    - Real-time control and monitoring
  - Event manager

- **Abstraction**
  - Data plane APIs: OF Agent
  - C-plane Radio API: FlexRAN Agent
LL-MEC implementation

- LL-MEC controller
  - From scratch in C++ and Python
  - x64 Linux support
  - Core network programmability coordinated with RAN real-time operation
  - Flexible application programming environment at the network edge
  - Apache V2.0 license
  - OpenFlow rules support

- GTP enabled OVS
  - OVS 2.7.0 applied with GTP patch
  - x64 Linux support (4.7 kernel)
  - Apache V2.0 license
## LL-MEC API

<table>
<thead>
<tr>
<th>API</th>
<th>Target</th>
<th>Direction</th>
<th>Example</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add UE / Slice</td>
<td>UE, Slice</td>
<td>EPC → Slice</td>
<td>• Create session request&lt;br&gt;• SGi endpoint update&lt;br&gt;• Slice create</td>
<td>• Core network CU&lt;br&gt;• S-GW-C</td>
</tr>
<tr>
<td>Delete UE / Slice</td>
<td>UE, Slice</td>
<td>EPC → Slice</td>
<td>• Release access bearer request&lt;br&gt;• SGi endpoint update&lt;br&gt;• Slice destroy</td>
<td>• Core network CU&lt;br&gt;• S-GW-C</td>
</tr>
<tr>
<td>Get UE / Slice info</td>
<td>UE, Slice</td>
<td>EPC → Slice</td>
<td>• Scheduling decisions&lt;br&gt;• Coordinated slicing</td>
<td>• Monitoring</td>
</tr>
<tr>
<td>Redirect UE / Slice</td>
<td>UE, Slice</td>
<td>EPC → Slice</td>
<td>• Video optimization&lt;br&gt;• IoT gateway</td>
<td>• Control actions&lt;br&gt;• Programmability</td>
</tr>
<tr>
<td>Get flow statistic</td>
<td>Stats</td>
<td>EPC → Slice</td>
<td>• Traffic shaping</td>
<td>• Monitoring</td>
</tr>
</tbody>
</table>
Real-time application

Elastic Application (e.g. Content/Video optimization)

Low Latency Application (e.g. low latency E2E slice)

Task Manager

Register

Rest APIs, Mbus

Schedule, Start, Stop, Pause

Core APIs, Mbus

Schedule, Start, Stop, Pause

Low Priority

High Priority
LL-MEC apps

- Video optimization
- Load balancing
- Content caching
- Recommendation system
- Traffic steering
- E2E network slicing
- Dedicated core network
- IoT Gateway
LL-MEC Scalability

**Default Bearer**

**Dedicate Bearer**
## LL-MEC Compatibility

<table>
<thead>
<tr>
<th></th>
<th>Setup</th>
<th>MB/sec</th>
<th>Std. dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Downlink</strong></td>
<td>Legacy LTE</td>
<td>15.691</td>
<td>1.648</td>
<td>11.5</td>
<td>18.9</td>
</tr>
<tr>
<td></td>
<td>LL-MEC</td>
<td>15.112</td>
<td>0.67</td>
<td>14.9</td>
<td>16.7</td>
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<tr>
<td><strong>Uplink</strong></td>
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<td>1.059</td>
<td>4.19</td>
<td>11.5</td>
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<tr>
<td></td>
<td>LL-MEC</td>
<td>8.197</td>
<td>0.644</td>
<td>7.34</td>
<td>9.44</td>
</tr>
</tbody>
</table>

- Mosaic-5G LL-MEC and OVS-GTP (OVS 2.5.1, Kernel-based GTP support)
- OpenAirInterface OAI-RAN and OAI-CN snaps
- Real RF front-end Ettu B210 USRP
- COTS User Equipment (UE)
- 5MHz channel bandwidth in band 7
A massive packet drop takes place due to CPU overloading when using legacy setting.
Network Slicing
- Shared vs. Dedicated data plane to support isolation

Network Setup
- A total of 2000 UEs per IOT Silo
Useful links

- Slicing and orchestration in service-oriented 5G architecture
- LL-MEC: An SDN-based MEC Platform
- LL-MEC platform
- How to enable DP programmability in mobile network?
Mosaic5G-Contact

E-mail: llmec@mosaic-5g.io
Website: mosaic-5g.io
Twitter: @mosaic5g
Linkedin: mosaic-5g