### Background and Motivation

- Traffic demand is expected to be ever-increasing in future years.
- Mobile data revenue is falling fast.
- Impacts on the dimensioning and planning:  
  - I. Spectrum is limited and expensive;
  - II. Deployed mobile core networks are highly hierarchical and centralised.
- **iJOIN** increases the overall bandwidth available to users by using smaller cells.
- **iJOIN** moves the complexity to the cloud introducing the RANaaS concept.
- This approach raises challenges in network selection and mobility management.

### Proposed mobility solution

- **IP** based solution following an **SDN**-focused approach.
- Distributed **IP** anchoring with flow-level granularity.
- Support for **IP** local breakout.
- **IP** flows may not traverse the **BH** and network operator’s core.
- Key role played by the **iJOIN** network controller (INC):
  - I. Centralised and joint optimization of RAN and **BH**;
  - II. Anchor selection and mobility management.

### Hardware platform

- **Alix** boards: single board computers with two 100BASE-TX Ethernet interfaces and one 802.11g wireless card.
- **Dink** DGS-122T: 24 ports 100BASE-TX Ethernet switch, 802.1Q capable.
- Two commodity laptops.

### Software platform

- GNU/Linux (Voyage Linux) running kernel 3.10 installed on **Alix** boards.
- GNU/Linux without any modification installed on both laptops.
- **Open VSwitch** 2.0.1 with **OpenFlow** 1.3 support used on **Alix** boards.
- **RYU** as **SDN** controller installed on one laptop.

### SDN-Testbed deployment

- **Logical topology**
  - 802.1Q capable Ethernet switch used for emulating network topology.
  - Topology is emulated only for Data plane, Control plane topology is flat.
  - Multiple Linux virtual VLAN interfaces on **Alix** Data plane’s Ethernet interface.
  - By properly configuring VLANs on the switch and on the **Alix** boards, we can emulate any desired topology for the Data plane.

### Functional architecture

- **SDN-based** functional architecture in the **INC**.
- **Reduced iJOIN functional architecture**.
- 8 modules implemented as Ryu applications.
- Event-driven communication between modules.

### Results

<table>
<thead>
<tr>
<th>Total HO time</th>
<th>HO time composition</th>
<th>HO impact on TCP</th>
</tr>
</thead>
<tbody>
<tr>
<td>95% pctl Layer 2 HO time: 21ms.</td>
<td>Processing time in the <strong>INC</strong></td>
<td>TCP stream generated with <strong>iperf</strong></td>
</tr>
<tr>
<td>95% pctl Layer 2+3 HO time: 46ms.</td>
<td>Configuration time increase linearly with # of anchors.</td>
<td>TCP seq. numbers tends to increase linearly despite the handovers.</td>
</tr>
<tr>
<td>95% pctl for ping dcm time: 54ms.</td>
<td>Majority of the time spent on configuring the anchors.</td>
<td></td>
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