PoliFi: Airtime Policy Enforcement for WiFi

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IEEE WCNC
Marrakech, April 2019
Outline

- Background
- PoliFi design
- Evaluation
- Future work
Main Contributions

PoliFi is an airtime policy enforcement system that:

- Supports individual station and group policies
- Runs entirely on the access point
- Is included in the mainline Linux kernel from v5.1
Background

- 802.11 Performance Anomaly
- Previous Work: Airtime Fairness Scheduler
802.11 Performance Anomaly

Effective transmission time $T(i)$ and rate $R(i)$ (for station $i \in I$):

$$T(i) = \begin{cases} \frac{1}{|I|} & \text{with fairness} \\ \frac{T_{\text{data}}(i)}{\sum_{j \in I} T_{\text{data}}(j)} & \text{otherwise} \end{cases}$$

$$R(i) = T(i) R_0(i)$$

Where $R_0(i) = \frac{L_i}{T_{\text{data}}(i) + T_{\text{oh}}}$ is the effective rate of a station transmitting without collisions.
Previous Work: Airtime Fairness Scheduler

![Graph showing airtime fairness comparison between different scheduling methods: FIFO, FQ-CoDel, FQ-MAC, and Airtime fair FQ.]

- **FIFO**
- **FQ-CoDel**
- **FQ-MAC**
- **Airtime fair FQ**

<table>
<thead>
<tr>
<th>Fast 1</th>
<th>Fast 2</th>
<th>Slow</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>0.8</td>
<td>0.6</td>
</tr>
<tr>
<td>0.8</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>0.4</td>
<td>0.2</td>
<td>0.0</td>
</tr>
</tbody>
</table>

- **0.0**
- **0.2**
- **0.4**
- **0.6**
- **0.8**
- **1.0**
PoliFi Design

What if we don’t want straight fairness?
Design Goals

Enable airtime policy enforcement, supporting:

- Prioritising single devices
  - Use case, e.g.: “My TV needs more airtime”

- Balancing device groups
  - Use case, e.g.: 5G network slicing

- Limiting groups of devices to a maximum capacity share
  - Use case, e.g.: Guest network
PoliFi Design

Kernel
- Kernel subsystem
- mac80211 subsystem
- Station weights
- Station weight defects
- Weighted DRR scheduler
- Device driver
- WiFi hardware

Userspace
- Policy daemon
- User configuration
- Station state tracker

Set station weights
- Assoc/disassoc notifications
- Station queue state

Airtime usage
Operating Modes

Weights set by userspace daemon (hostapd), supporting three modes:

- **Static** mode: Specify MAC priority in config
- **Dynamic** mode: Specify weight per group (BSS)
- **Limit** mode: Like dynamic, but only limit some groups
Evaluation results

- 4 station test, 2 groups (BSSes)
- BSS 1: Stations 1, 2 and 3
- BSS 2: Station 4
Airtime usage - UDP

![Airtime usage chart]

- No policy
- Static
- Dynamic
- Limit

Airtime share

Station 1  Station 2  Station 3  Station 4
Station 1  Station 2  Station 3  Station 4
Station 1  Station 2  Station 3  Station 4
Station 1  Station 2  Station 3  Station 4

Airtime usage - UDP
- Toke Høiland-Jørgensen <toke@toke.dk>
BSS airtime usage - UDP and TCP

![Graph showing airtime share for BSS 1 and BSS 2 under dynamic and limit conditions.]

- Toko Høiland-Jørgensen <toke@toke.dk>
Reaction time - dynamic mode
Reaction time - limit mode

Airtime share

Time (s)
DASH video throughput

Time (s)

Mbits/s

0 100 200 300 400 500 600

0 2 4
Future work
Planned future work

Future work being discussed in upstream Linux:

- Switching to a virtual time-based scheduler
- Airtime estimation for devices that don’t provide it
- Airtime-based queue limits
Summary

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