Energy-Efficient 5G Networks: Optimization Meets SDN

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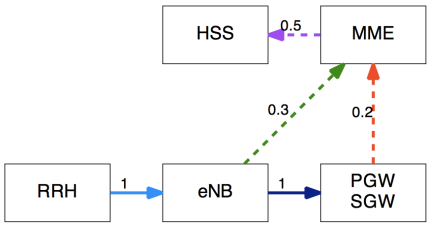
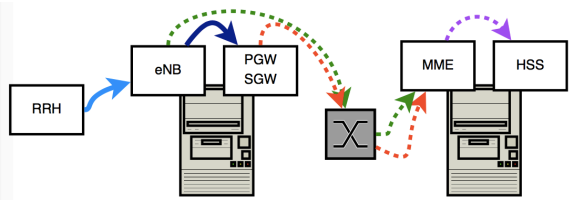
5GXCrosshaul
the integrated fronthaul/backhaul





Traffic flows are processed by **chains of VNFs**

Specific to each traffic type

In the example, virtual EPC

VNFs are hosted at hybrid, computation-capable **switches**

Often running on commodity hardware (Lagopus)

Three **joint decisions**:

- VNF placement
- Traffic routing
- Activating hardware

Objective: **energy** efficiency

Main **constraints**:

- Link capacity
- Hardware capabilities

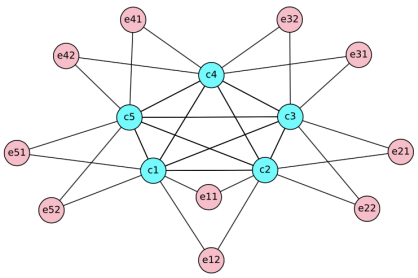
Optimization **in the loop**

The controller solves a relaxed LP problem in real time; relaxed variables are interpreted as priorities

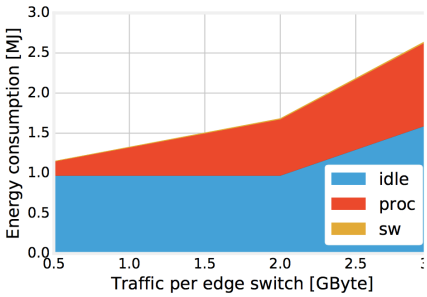
Algorithm 1 The `fixProblems` procedure.

Require: $\mathcal{P}^{\text{curr}}$

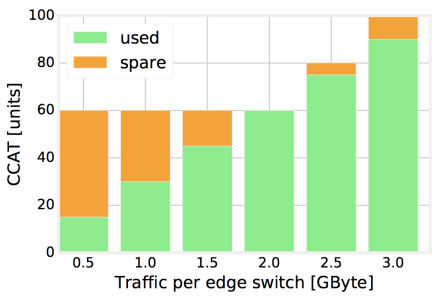
1: $\mathcal{P} \leftarrow$ **copy**$(\mathcal{P}^{\text{curr}})$
2: $\mathcal{P}$.fix$(x_{i,j} \leftarrow x_{i,j}^{\text{curr}}, \quad \forall (i,j) \in \mathcal{L})$
3: $\mathcal{P}$.fix$(y_c \leftarrow y_c^{\text{curr}}, \quad \forall c \in \mathcal{C})$
4: $\mathcal{P}$.fix$(\delta(c,v) \leftarrow \delta^{\text{curr}}(c,v), \quad \forall c \in \mathcal{C}, v \in \mathcal{V})$
5: **solve**$(\mathcal{P})$
6: **if** $\mathcal{P}$.is_feasible **then**
7: **return**
8: **if** link-capacity$\in \mathcal{P}$.IIS **then**
9: $\mathcal{P}$.relax$(x_{i,j} : x_{i,j}^{\text{curr}} = 0)$
10: $\mathcal{P}$.relax$(y_c : y_c^{\text{curr}} = 0)$
11: $\tilde{x}, \tilde{y} \leftarrow$ **solve**$(\mathcal{P})$
12: $(i^\star, j^\star) \leftarrow$ **choose** from $\mathcal{L}$ with pr. $\tilde{x}_{i,j}$
13: $\mathcal{P}$.fix$(x_{i^\star,j^\star} \leftarrow 1)$
14: $\mathcal{P}$.fix$(y_i \leftarrow 1; y_j \leftarrow 1)$
15: **goto** Line 5
16: **if** switch-capacity$\in \mathcal{P}$.IIS **then**
17: $\mathcal{P}$.relax$(\delta(c,v) : \delta^{\text{curr}}(c,v) = 0)$
18: $\tilde{\delta} \leftarrow$ **solve**$(\mathcal{P})$
19: $c^\star, v^\star \leftarrow$ **choose** from $\mathcal{C} \times \mathcal{V}$ with pr. $\tilde{\delta}(c,v)$
20: $\mathcal{P}$.fix$(\delta(c^\star, v^\star) \leftarrow 1)$
21: **goto** Line 5



Tested on a simple, **synthetic** topology



Main contributions: **idle** and **processing** energy consumption



As traffic increases, **deploy** more switches and use them more