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Base-Band Unit Function Split Placement for C-RAN

Niezi MHARSI

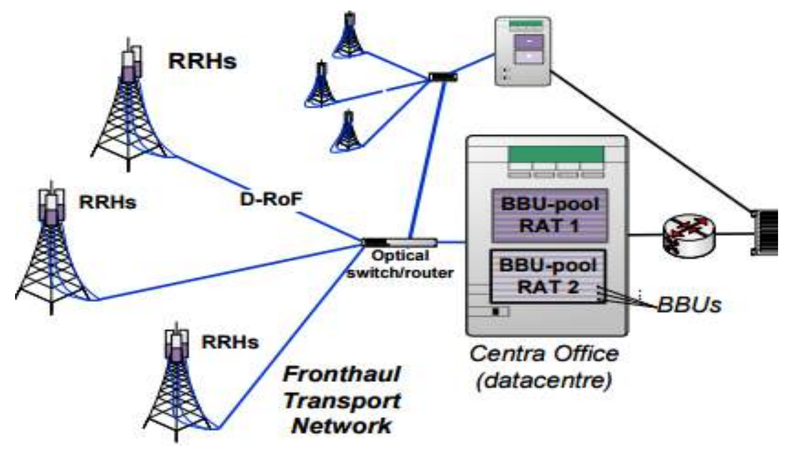
Philippe Martins[1] (directeur), Makhlouf Hadji[2] (encadrant)

[1] LTCI, Télécom ParisTech, [2]IRT SystemX

1. CONTEXT

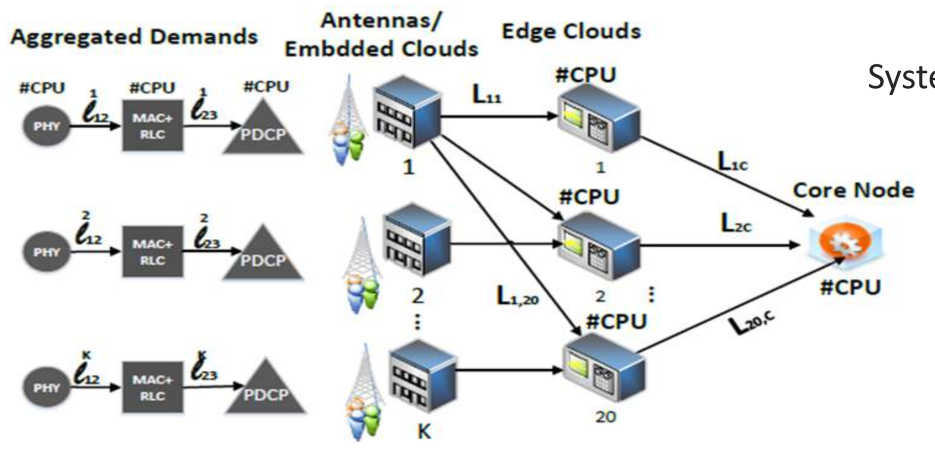
C-RAN (Cloud-Radio Access Network) is a new cellular network architecture considered as a key enabler for the next generation mobile networks. This can be achieved by an optimal split/placement BaseBand Unit (BBU) functions.

C-RAN Architecture



2. OBJECTIVE

We investigate new algorithms to optimally split BBU functions (PHY, MAC+RLC, PDCP) while meeting jointly the sequencing chains on the physical network in terms of CPU and latency requirements.



System Model

3. BBU FUNCTION SPLIT PLACEMENT ALGORITHM

Integer Linear Programming Formulation

$$\min \sum_{k\in\mathscr{A}}\sum_{j\in\mathscr{V}}\sum_{j'\in\mathscr{P}(j)}\sum_{i\in\{1,2\}} L(j,j')\,y^k_{(i,i+1)} \sum_{j\in\mathscr{V}}\left(C_j z_j - \sum_{k\in A}\sum_{i\in\mathscr{V}_v} c_i^k x_{i,j}^k\right)$$

$$\sum_{j\in\mathscr{V}_1} \mathbb{1}_{(k,j)} x^k_{1,j} = 0, \forall k\in\mathscr{A}$$

$$\sum_{j\in\mathscr{V}} x^k_{i,j} = 1, \forall k\in\mathscr{A}, \forall i\in\{1,2,3\}$$

$$\sum_{k\in\mathscr{A}}\sum_{i\in\{1,2,3\}} x^k_{i,j}\times c^k_i \le C_j, \forall j\in\mathscr{V}$$

$$x^k_{i,j} \le \sum_{j'\in\mathscr{P}(j)} x^k_{i+1,j'}, \forall k\in\mathscr{A}, \forall i\in\{1,2\}, \forall j\in\mathscr{V}$$

$$\sum_{j'\in\mathscr{P}(j)} y^k_{(i,i+1);(j,j')} = x^k_{i,j}, \forall k\in\mathscr{A}, \forall i\in\{1,2\}, \forall j\in\mathscr{V}$$

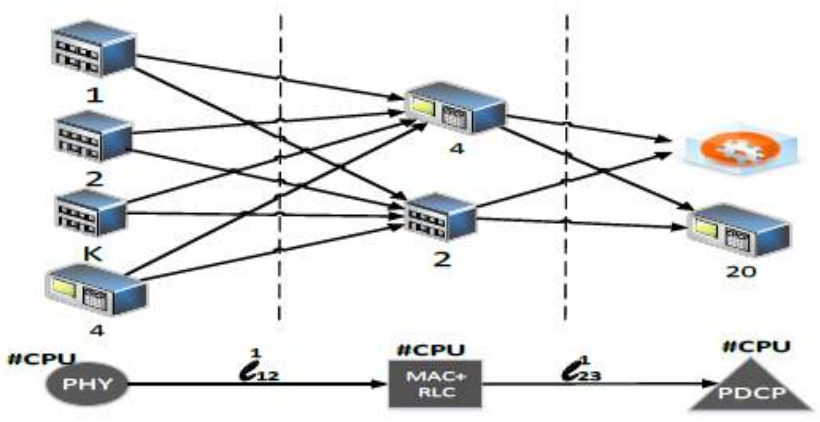
$$\sum_{j\in\mathscr{V}} y^k_{(i,i+1);(j,j')} = x^k_{i+1,j'}, \forall k\in\mathscr{A}, \forall i\in\{1,2\}, \forall j'\in\mathscr{P}(j)$$

$$\sum_{j\in\mathscr{V}}\sum_{j'\in\mathscr{P}(j)} y^k_{(i,i+1);(j,j')} = 1, \forall k\in\mathscr{A}, \forall i\in\{1,2\}$$

$$L_{(j,j')}\times y^k_{(i,i+1);(j,j')} \le l^k_{(i,i+1)}, \forall k\in\mathscr{A}, \forall i\in\{1,2\}, \forall j\in\mathscr{V}, \forall j'\in\mathscr{P}(j)$$

$$x^k_{i,j} \le z_j, \forall j\in\mathscr{V}, \forall k\in\mathscr{A}, \forall i\in\mathscr{V}_v$$

A Multi-stage Graph based heuristic



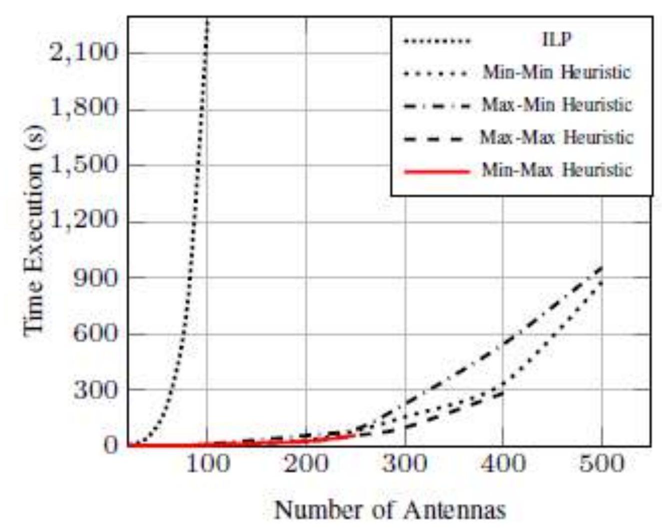
A multi-stage approach example

4. NUMERICAL RESULTS

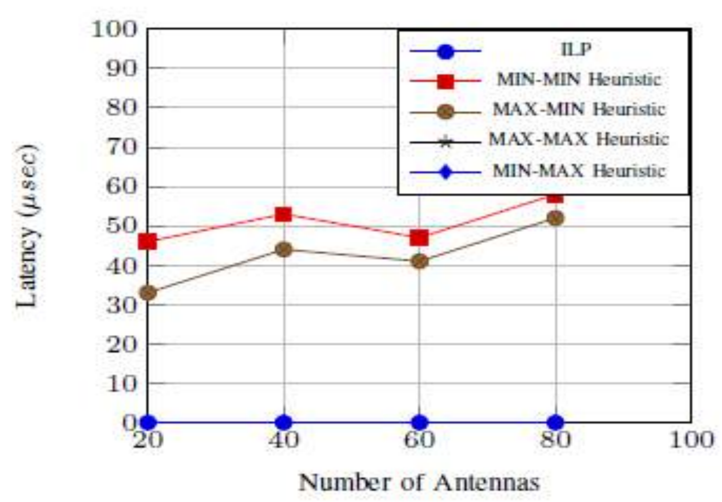
Algorithms performance comparison: ILP Vs Heuristics

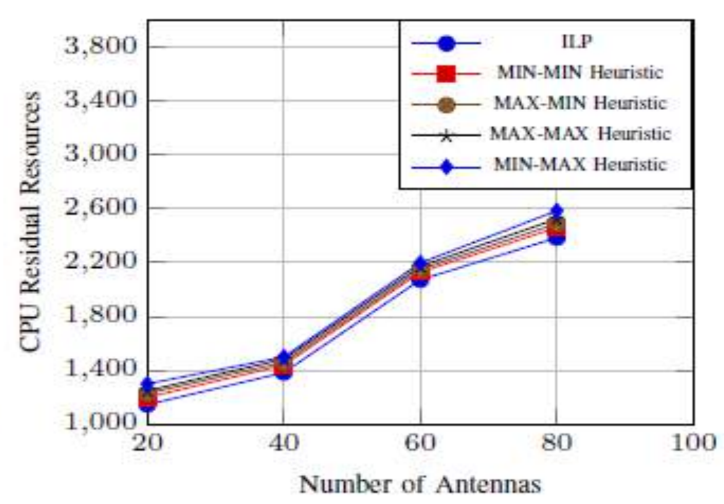
#Antennas	#Edge Clouds	Variant	Euclidean Graph Cost Gap (%)	Random Graph Cost Gap (%)
60	10	min-min	0	3.07
		min-max	0	0
		max-min	**2.96**	2.62
		max-max	0	0
	15	min-min	0	2.79
		min-max	0	0
		max-min	2.24	2.22
		max-max	0	0
	20	min-min	1.88	2.11
		min-max	0	0
		max-min	2.05	1.94
		max-max	0	0
80	10	min-min	2.49	3.08
		min-max	0	0
		max-min	2.64	2.56
		max-max	0	0
	15	min-min	2.92	2.76
		min-max	0	0
		max-min	2.3	2.32
		max-max	0	0
	20	min-min	2.55	2.28
		min-max	0	0
		max-min	1.87	2.0
		max-max	0	0

#Antennas	#Edge Clouds	Heuristic Variant	Heuristic Execution Time (s)	ILP Execution Time
200	10	min-min	42.51	>12h
		min-max	-	
		max-min	82.15	
		max-max	35.43	
	15	min-min	<1min	>15h
		min-max	-	
		max-min	<2min	
		max-max	43.01s	
	20	min-min	<1min	>16h
		min-max	<1min	
		max-min	<2min	
		max-max	<1min	



CPU Residual resources and Latency behavior





5. CONCLUSION & FUTURE WORK

Numerical results revealed the efficiency of the proposed approaches (ILP & Heuristics) to attend the optimum in negligible time.

Future work will consider BBU function split placement when dealing jointly with CPU and radio resource constraints.

REFERENCES

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Scientific domain: Infrastructure and Networks
Program: Internet of Trust
Project: Telecommunications and Cloud Services (STC)

Doctoral school: Sciences et technologies de l'information et de la communication (STIC)
Institution: Université Paris-Saclay

Contacts:
niezi.mharsi@irt-systemx.fr
makhlouf.hadji@irt-systemx.fr
philippe.martins@telecom-paristech.fr