Minimum Cost Deployment of Radio and Transport Resources in Centralized Radio Architectures

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Outline

- Capacity to indoor users in a 5G scenario
- Centralized Radio Architectures (CRA)
- Deployment strategies for CRA
- Results
- Conclusions

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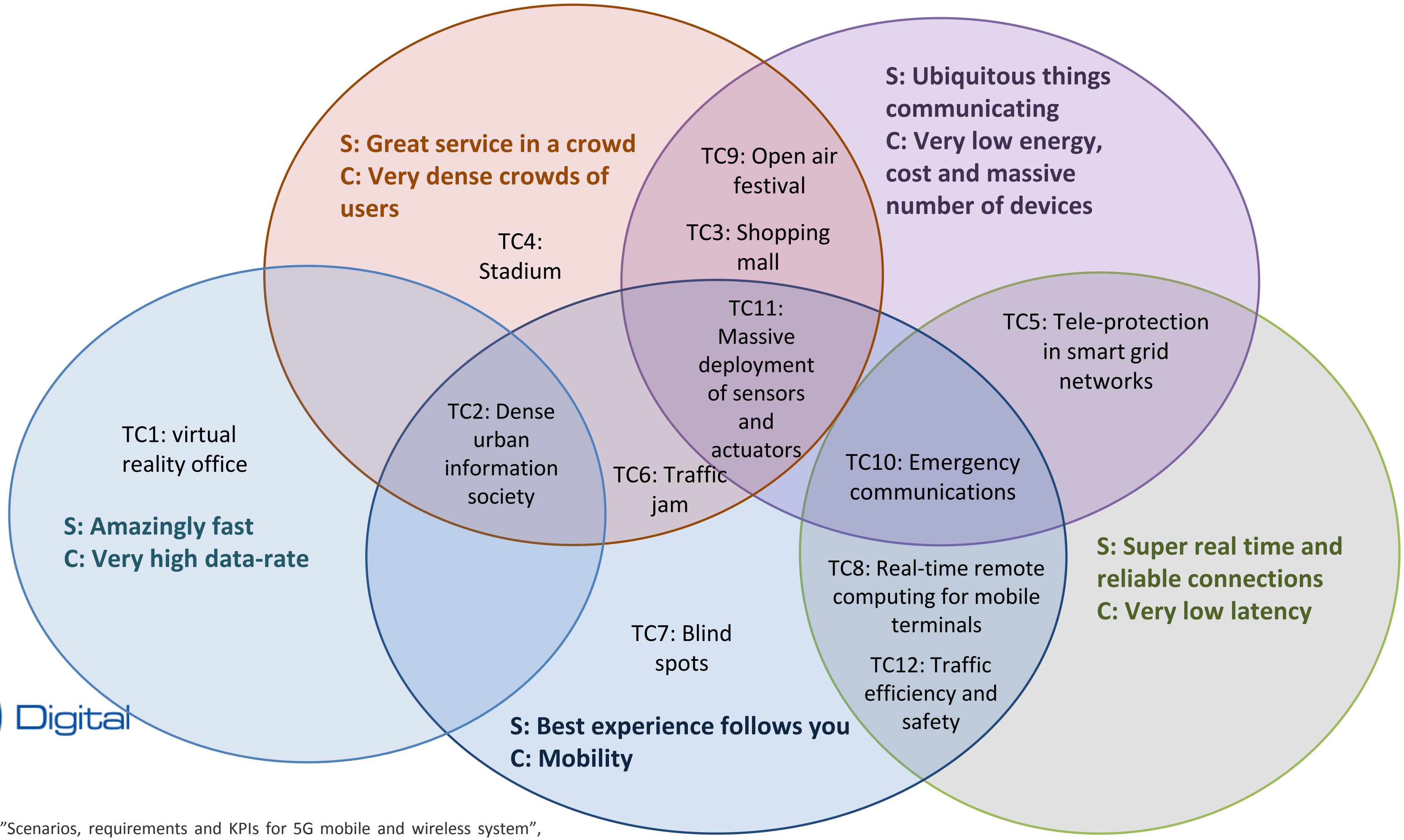
European Institute of Technology (EIT) Digital project EXAM (”Energy efficient Xhaul and M2M”)

5G wireless paradigm

- EU FP7 METIS 2020 project[1] defined 5G in terms of scenarios (S)
- Each scenario introduces a challenge (C) and multiple test cases (TC)



[1]METIS deliverable D1.1, "Scenarios, requirements and KPIs for 5G mobile and wireless system", April, 2013.

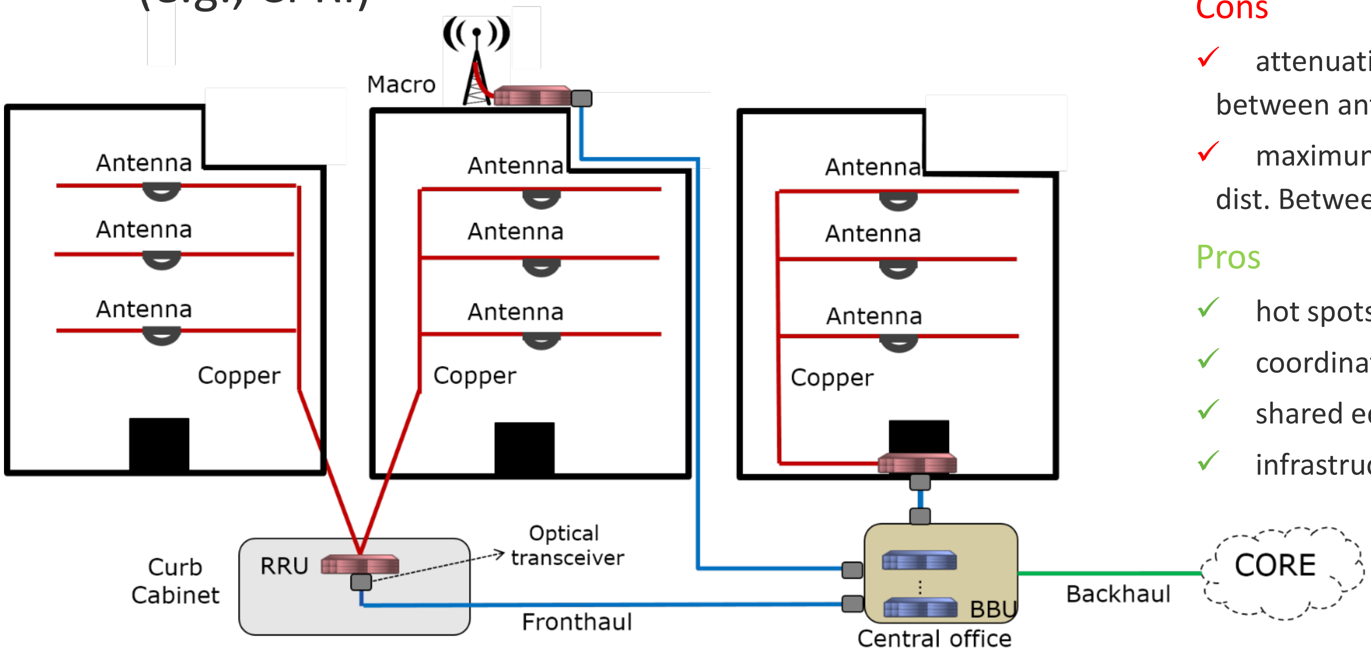
Broadband capacity to indoor users

- Data traffic is expected to reach 24.3 Exabytes/month by 2019 with 70% of this traffic originating from indoor users
- Alternatives:
  - macro densification:
    - ✓ wall attenuation and high costs
  - heterogeneous networks: layer of (pico) cells in addition to MBS
    - ✓ no coordination and high interference
- Centralized Radio Architectures (CRA)[1]
  - some of the BS physical layer radio functionalities decoupled from the BS site and aggregated in selected locations
    - ✓ benefits indoor radio (hot spots)
    - ✓ provide coordination (reduced interference)

[1]Connecting the dots: small cells shape up for high performance indoor radio", Ericsson Review, December 2014.

Centralized Radio Architecture (CRA)

- Three main blocks:
  - ✓ antenna: compact, cover large area (100s m^2)
  - ✓ remote radio unit (RRU): digital signal proc. radio signal, connected to up to *k* antenna via Cat 5/6/7 copper cables
  - ✓ baseband unit (BBU): digital baseband processing (interf mng, cell coord)
- The fronthaul data are transmitted using either A-RoF or D-RoF technology (e.g., CPRI)



Cons

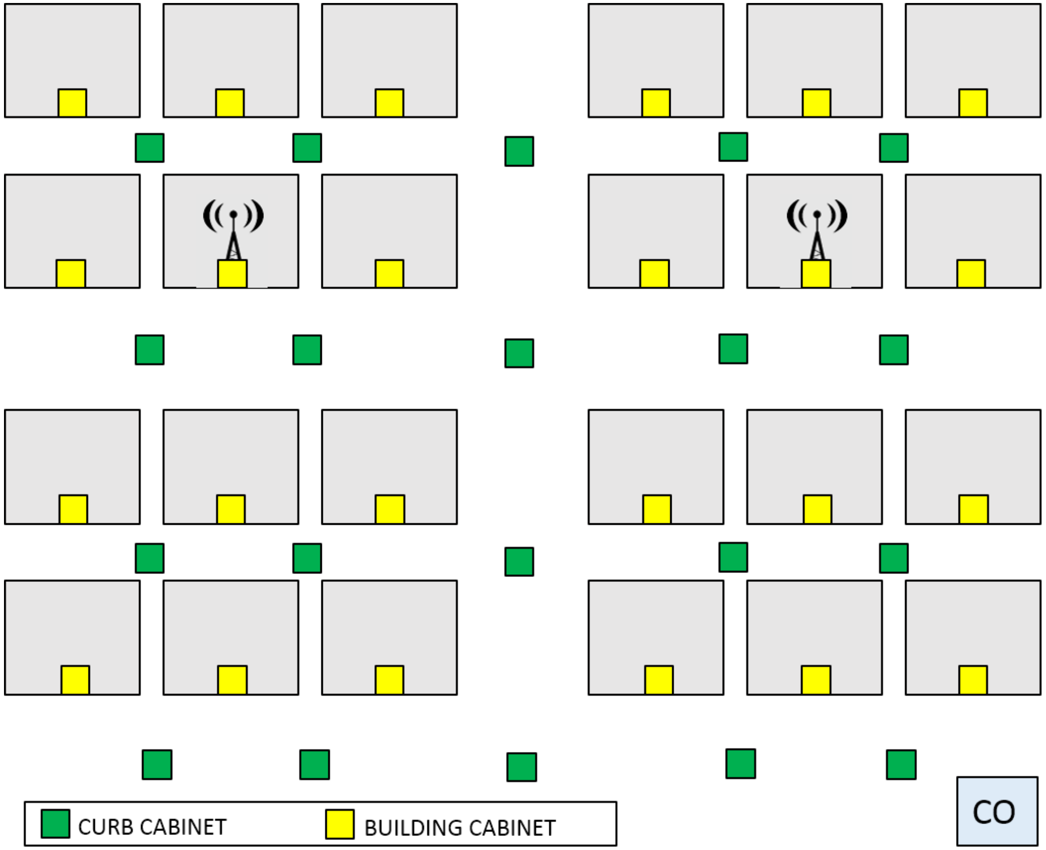
- ✓ attenuation over copper limits max dist. between antenna and RRU
- ✓ maximum latency in fronthaul links limit dist. Between RRU-BBU

Pros

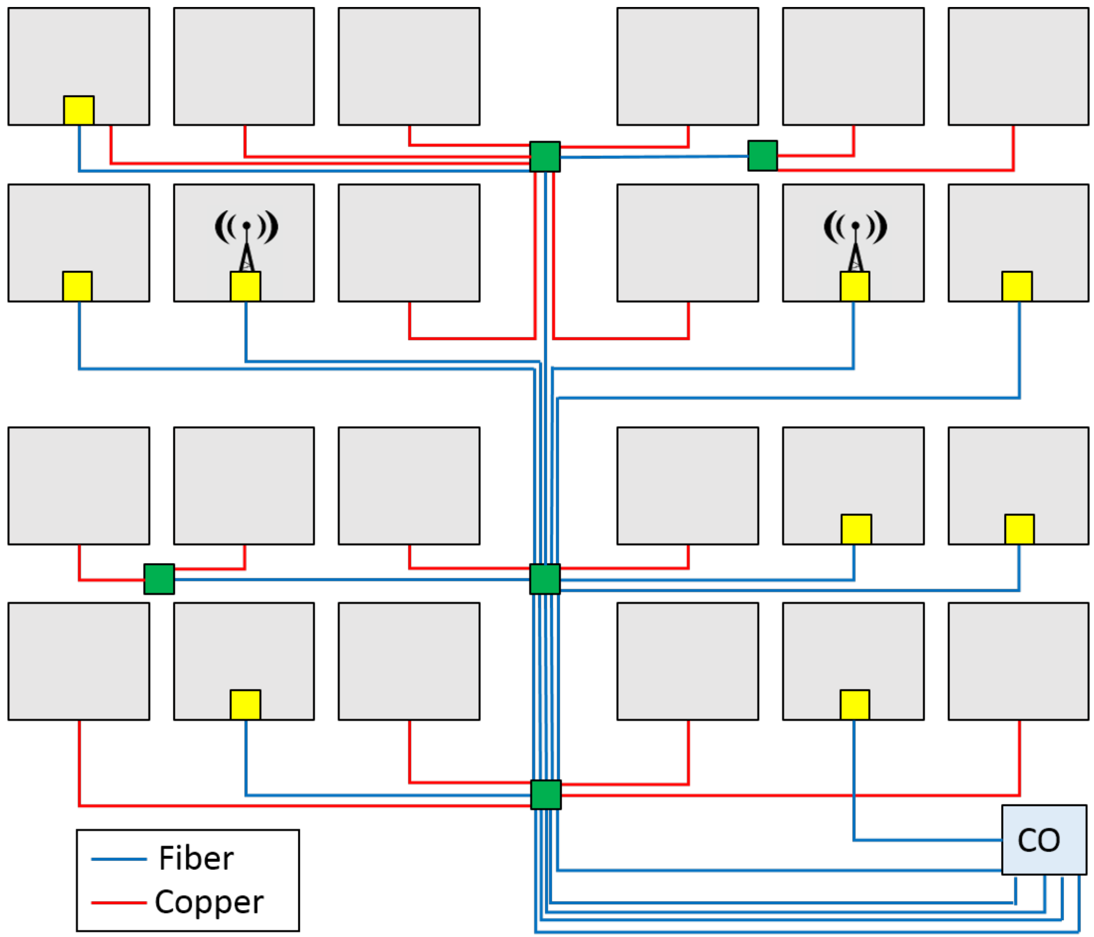
- ✓ hot spots
- ✓ coordination
- ✓ shared equipment
- ✓ infrastructure reuse

Problem description

- Green field scenario
- Given
  - ✓ building/duct layout
  - ✓ antenna # and loc.
  - ✓ possible RRU location
  - ✓ possible CO location
- RRU placement s.t.
  - ✓ min network equipment
  - ✓ min location to activate (min power supply and cooling)



Example of possible deployment



Problem formulation

- The minimum cost deployment of a CRA can be formally modelled via an ILP formulation with the following:

✓objective function:

$$Minimize\ \ \alpha \cdot \sum_{i \in R} r_i + \beta \cdot \sum_{i \in R} z_i$$

✓constraints:

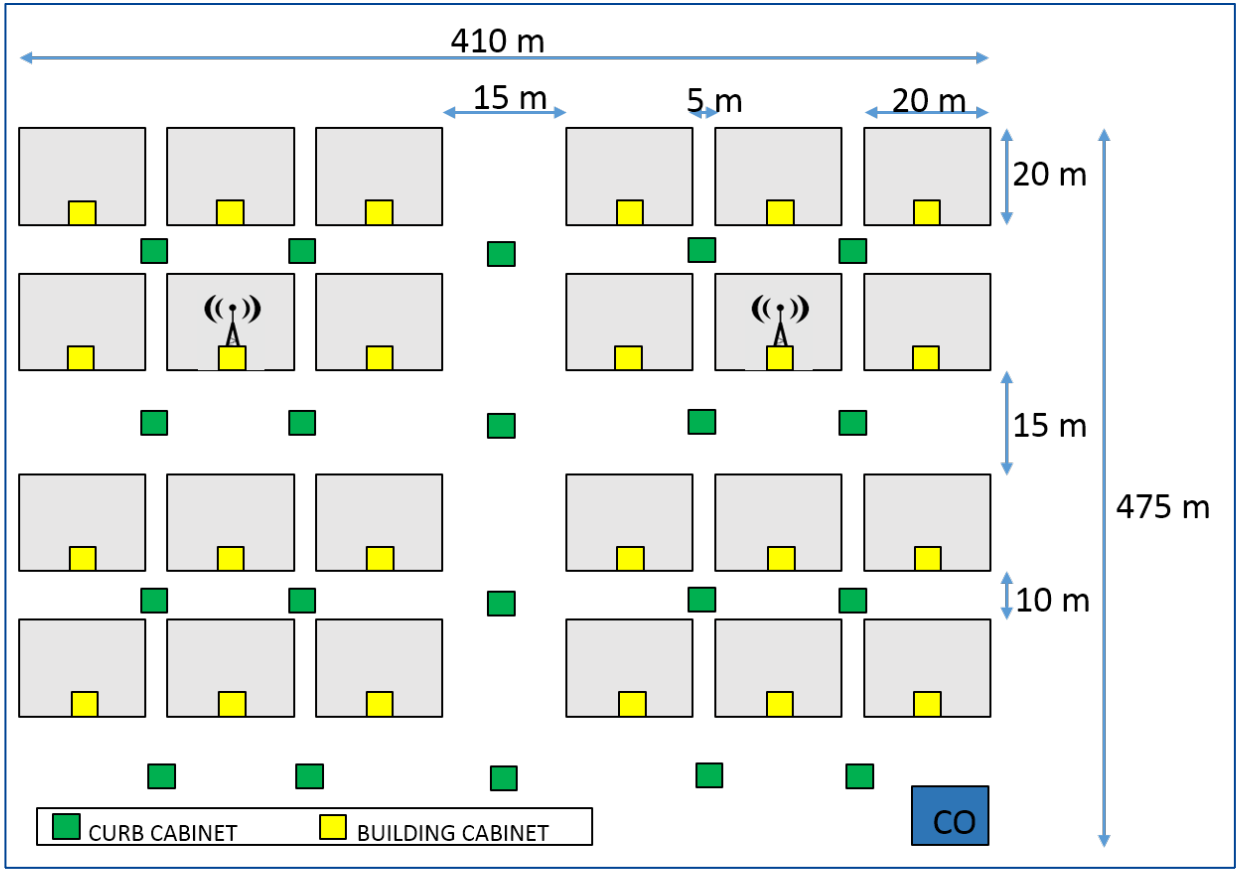
$$\sum_{i \in R} C_{ij} m_{ij} = 1, \forall j \in A$$

$$k \cdot r_i \geq \sum_{j \in A} C_{ij} m_{ij}, \forall i \in R$$

$$M \cdot z_i \geq r_i, \forall i \in R$$

Case study

- Manhattan street model, with building arranged in blocks
- 25 blocks organized in a 5 × 5 matrix, single block 6 buildings in a 6 × 2 matrix
- Total size 410x475 [m]
- Buildings 20x20 [m]
- Number of floors in each building = U{1,12}
- 1 antenna for each floor
- Cat 6 copper cable for antenna-RRU link
- Dedicated multimodal fiber for RRU-BBU link
- 2 Macro base stations
- k=8
- BBU unit 6 ports

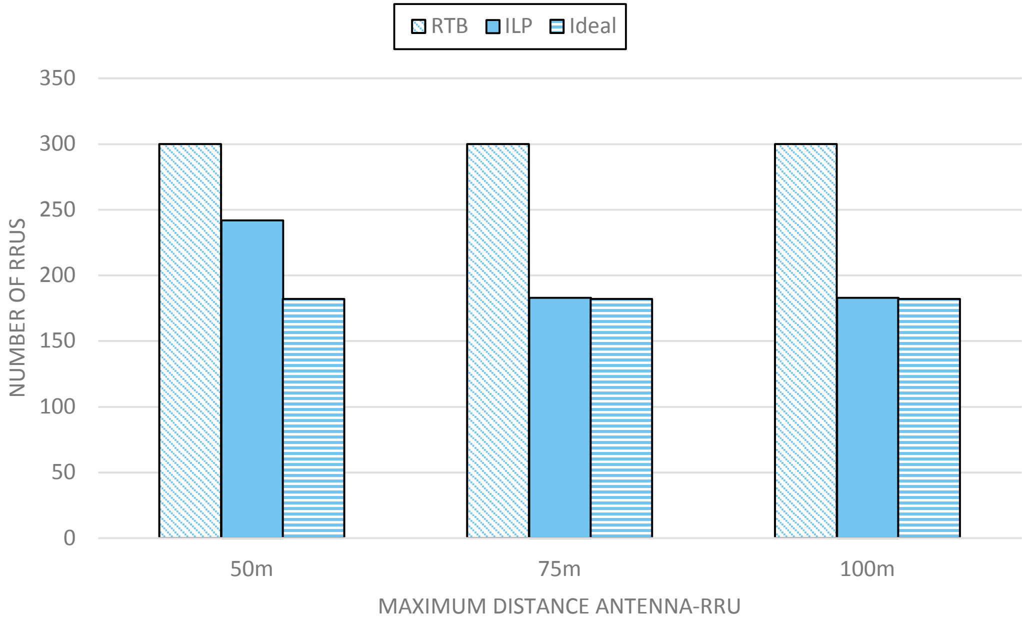


Benchmarking strategies

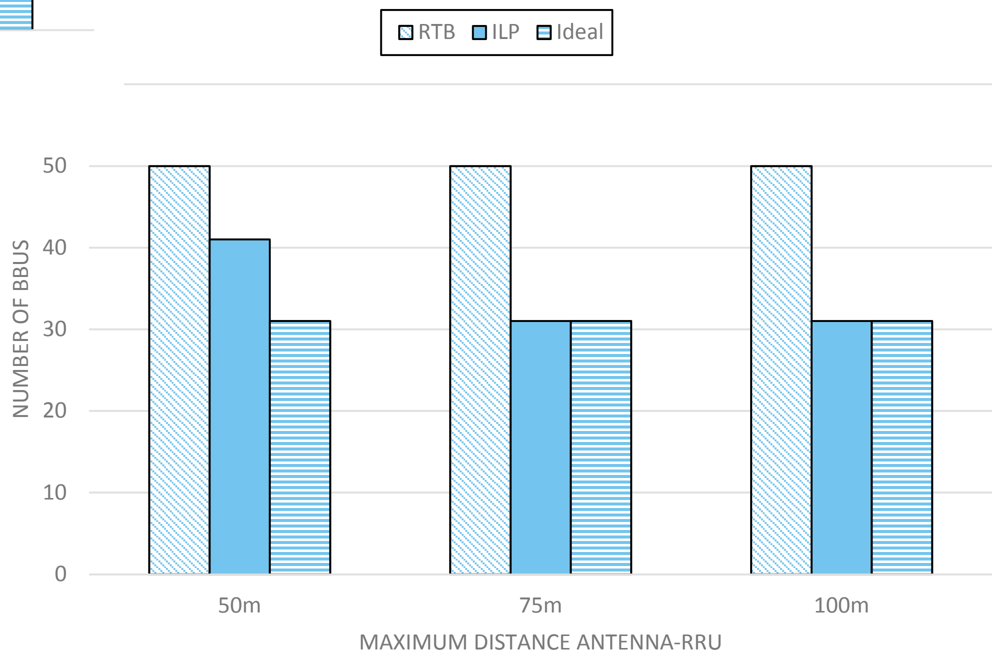
- **Radio-over-fiber To the Building (RTB)**:
  - ✓RRUs only inside buildings: no RRU sharing
  - ✓Fiber need to reach every building

- **Ideal**: theoretical minimum number of RRUs and BBUs required to cover the area (i.e., without any limitation on the length of the copper links)

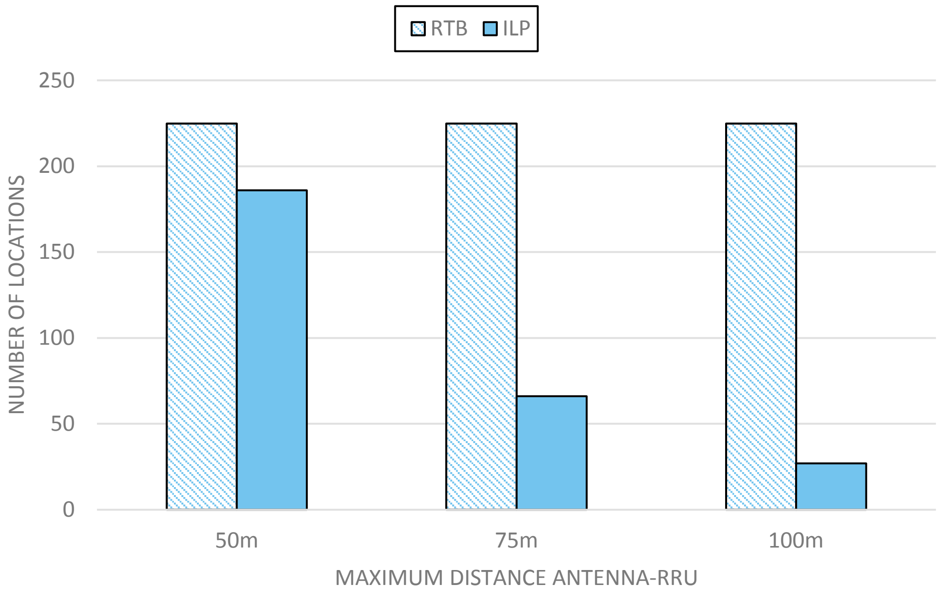
Amount of radio equipment



- Number of RRUs and BBUs required to cover the area very close to Ideal approach
- Almost 50% less than RTB



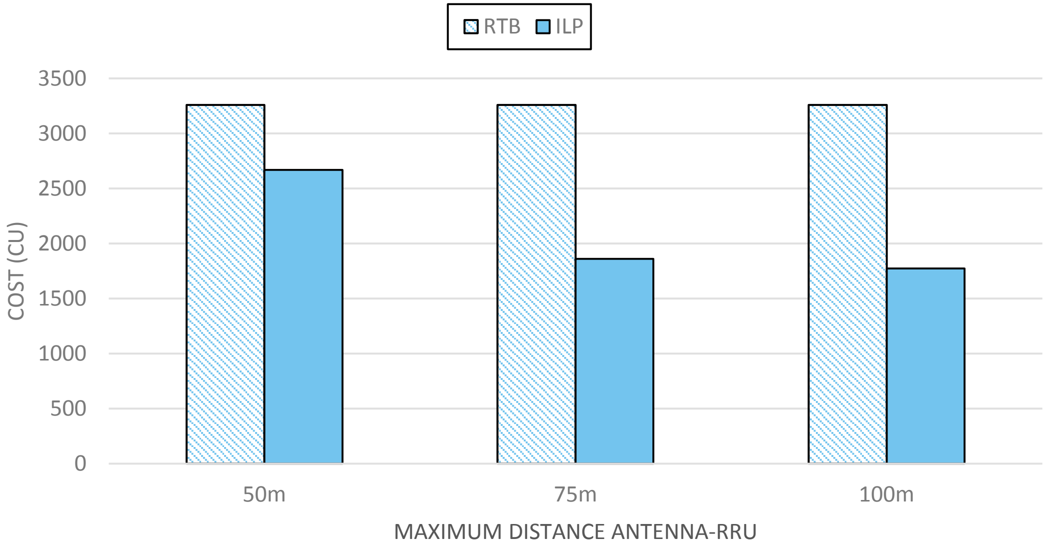
Number of active location and fiber length



- Significant reduction in # of active location
- Less (fiber) cables to be deployed

Algorithm	Copper cable (km)	Fiber cable (km)
ILP 50m	45.1	106.4
ILP 75m	82.0	79.9
ILP 100m	102.3	80.3
RTB	34.9	132.0

Infrastructure cost



- Cost reduction of almost 50%

Component	Normalized cost (CU)
SFP+	1
RRU	3.75
BBU	15
Cabinet	2.75
Copper cable (Cat. 6) (km)	1
Fiber cable (MMF) (km)	1

Conclusions

- Proposed a deployment strategy for mobile networks based on the CRA concept where the objective is cost minimization

- Provided an ILP formulation aimed at minimizing both the number of RRUs and the number of active sites in which RRUs are placed in a residential area

- The strategy is capable of significantly reducing the total network cost w.r.t. conventional deployment approach based on RoF to the building (RTB approach)

- Need to develop a heuristic algorithm able to scale to larger deployment scenarios

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