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OPTIMAL PLACEMENT OF FEMTO BASE STATIONS IN ENTERPRISE FEMTOCELL NETWORKS

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Outline

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- Motivation
- Introduction to HetNet Architecture
- Interference Problem in HetNet
- Optimized deployment of LTE Femto base station
- Experimental Results and Conclusion

Motivation

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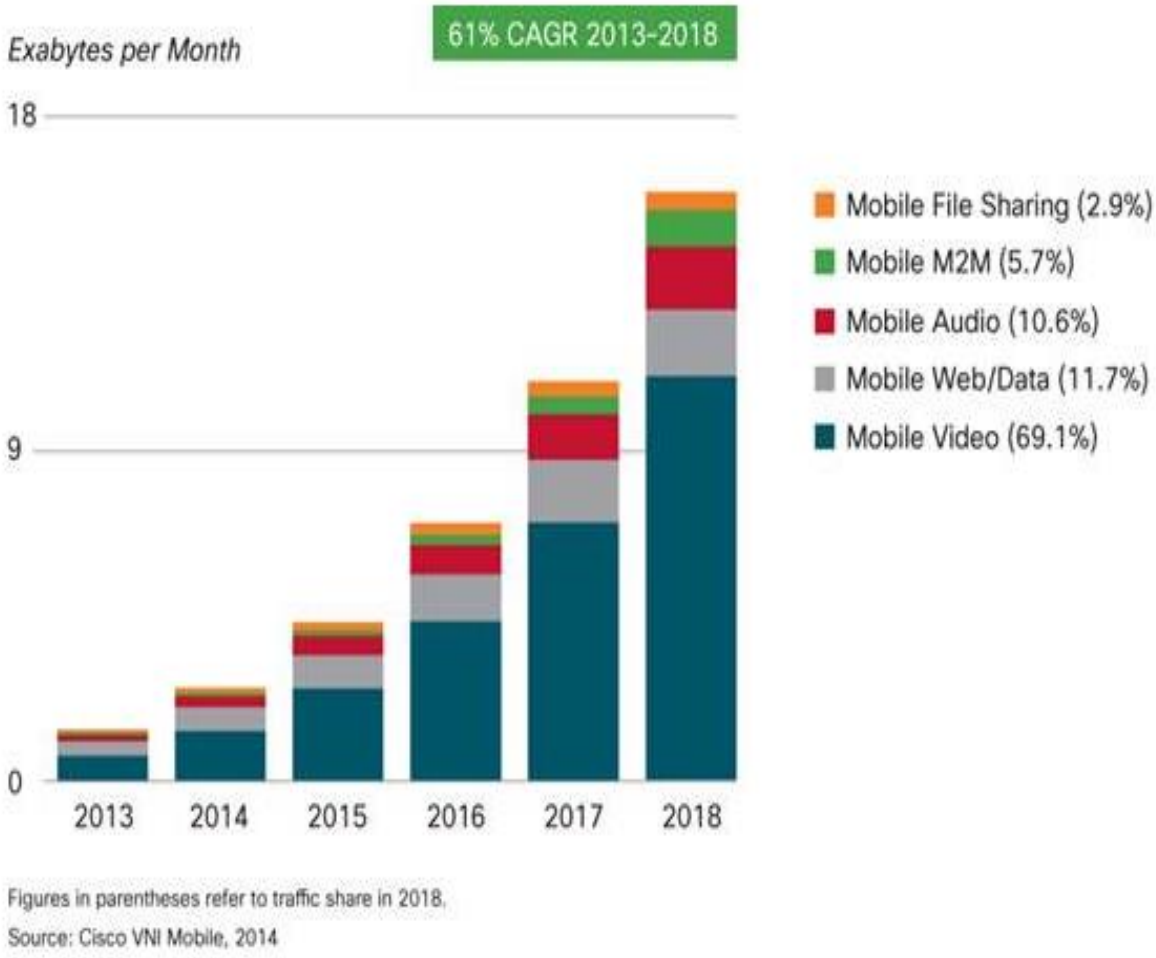
TREND 1

- In future video traffic will contribute to 70% of total cellular traffic.



So, BW demand is ever increasing.

Motivation

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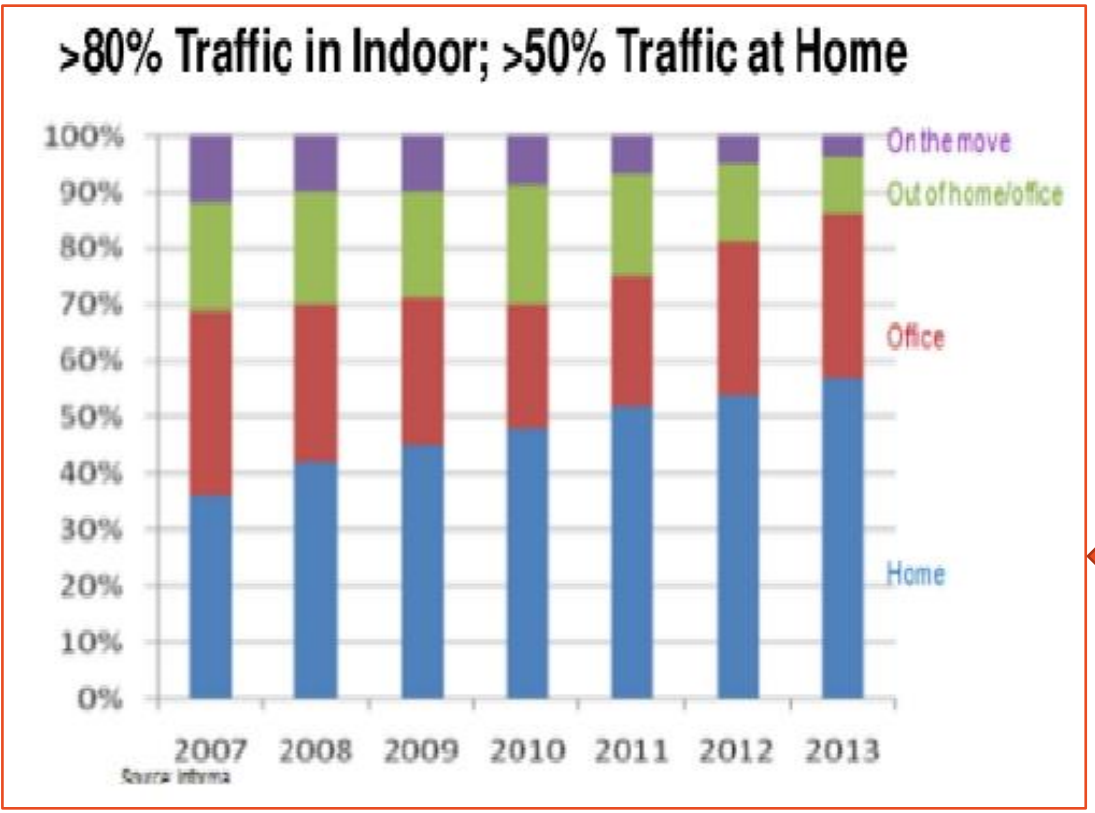
TREND 2



Issues in indoors:

- Poor cellular coverage
- So, low data rates

Most of traffic is from Indoor users

Solution: heterogeneous networks

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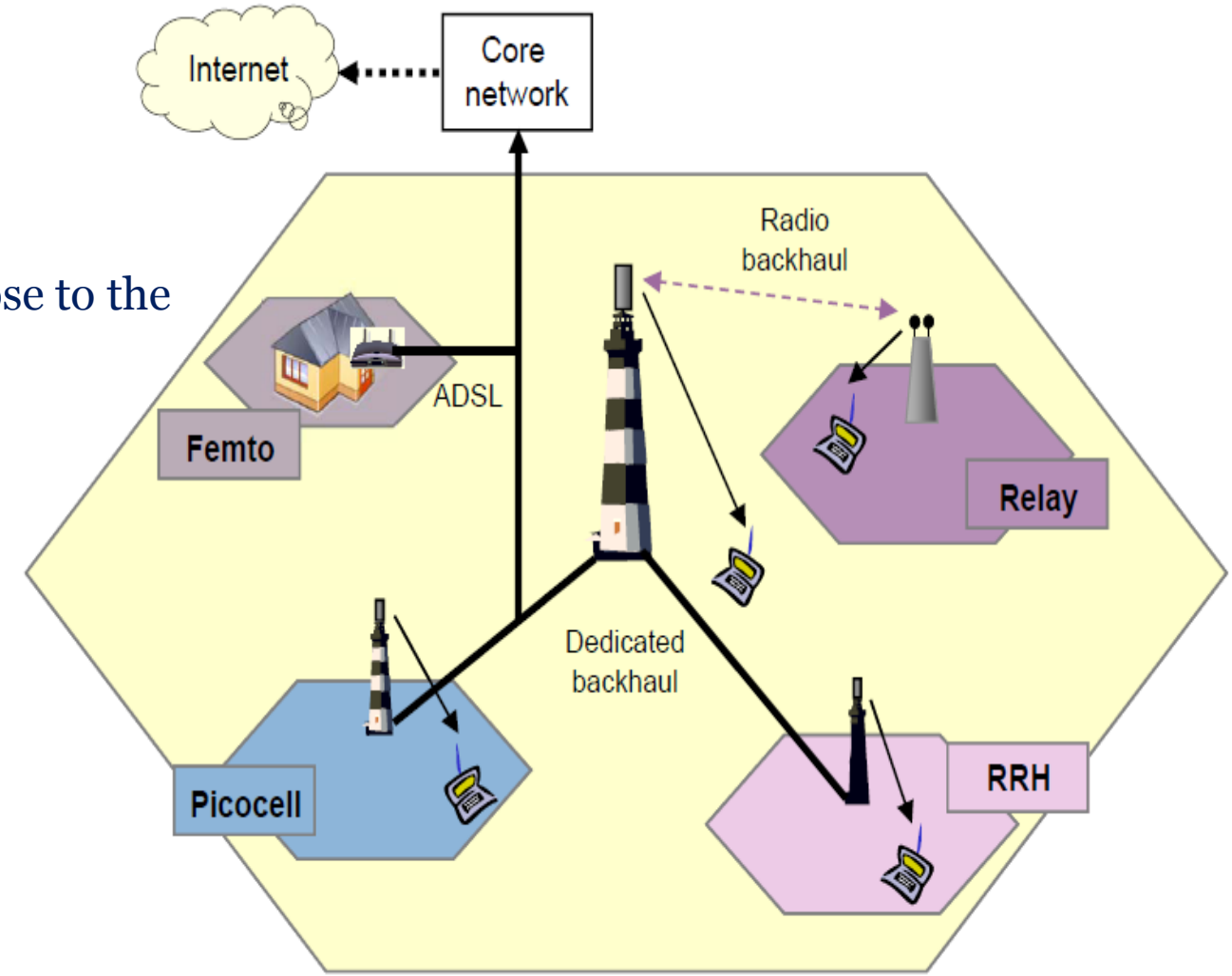
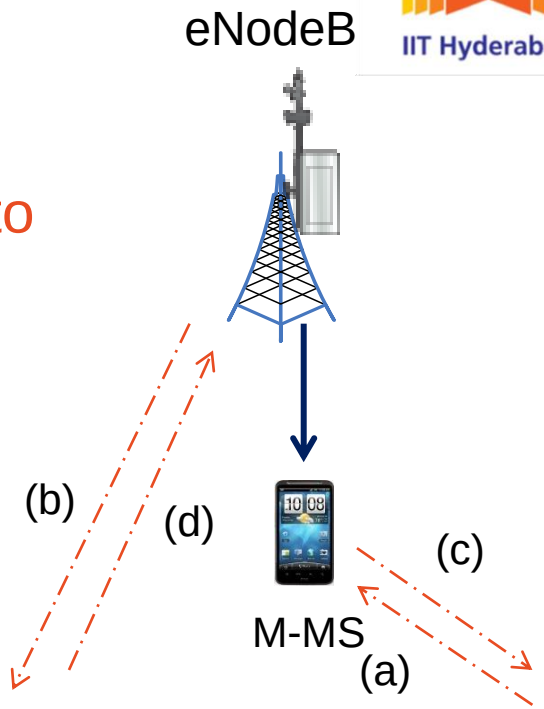
Advantages:

1. Increase in capacity
2. Bringing the service close to the users



Issues in HetNet

- Cross-tier interference
  -- Interference between Macro and Femto



Downlink Interference:

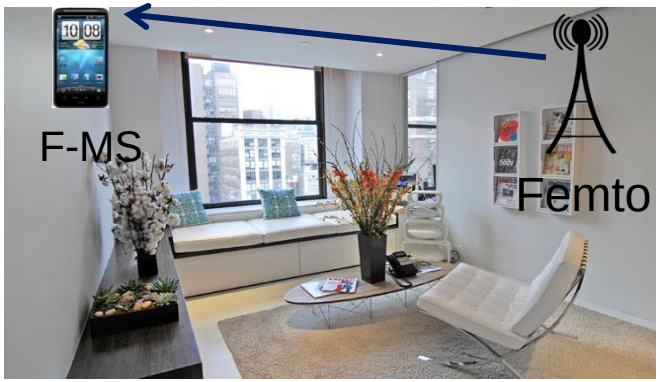
Case (a): Femto sends the downlink traffic to M-MS

Case (b): eNB sends the downlink traffic to F-MS

Uplink Interference:

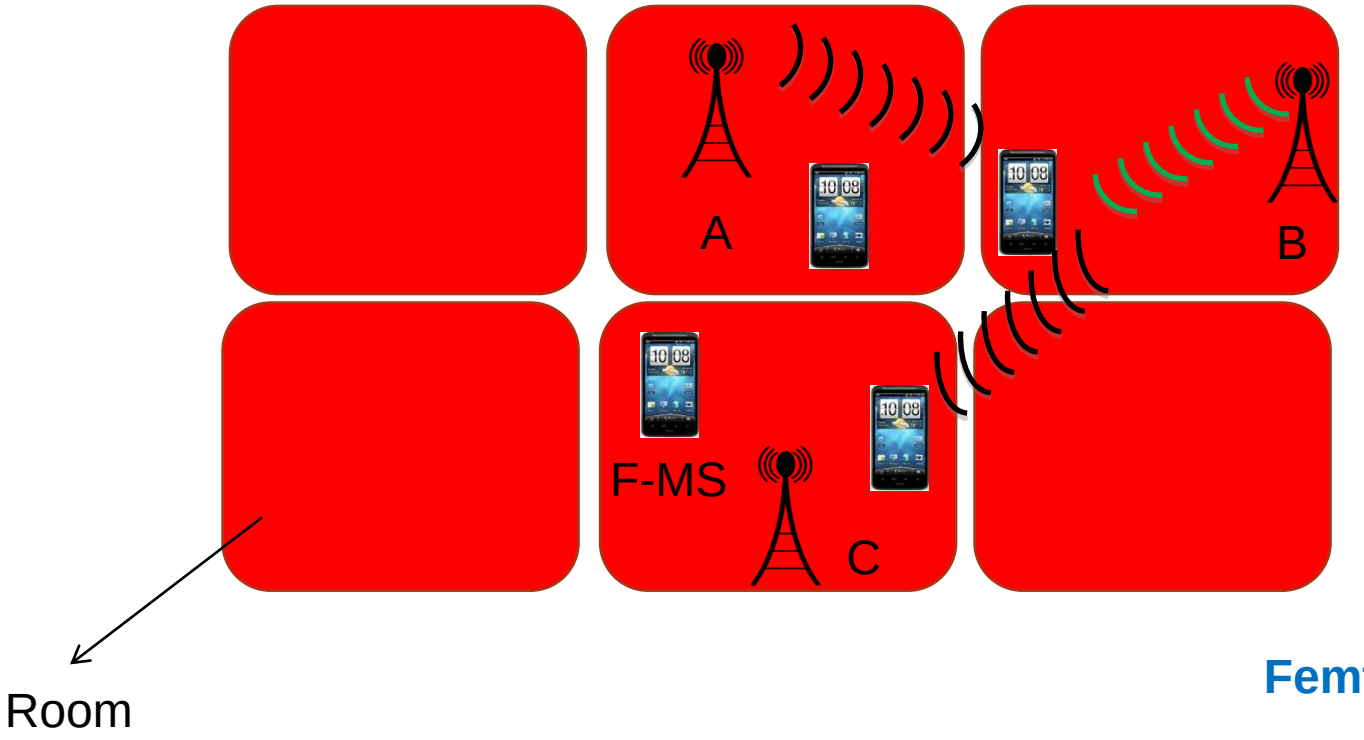
Case (c): M-MS sends the uplink traffic to Femto

Case (d): F-MS sends the uplink traffic to eNB



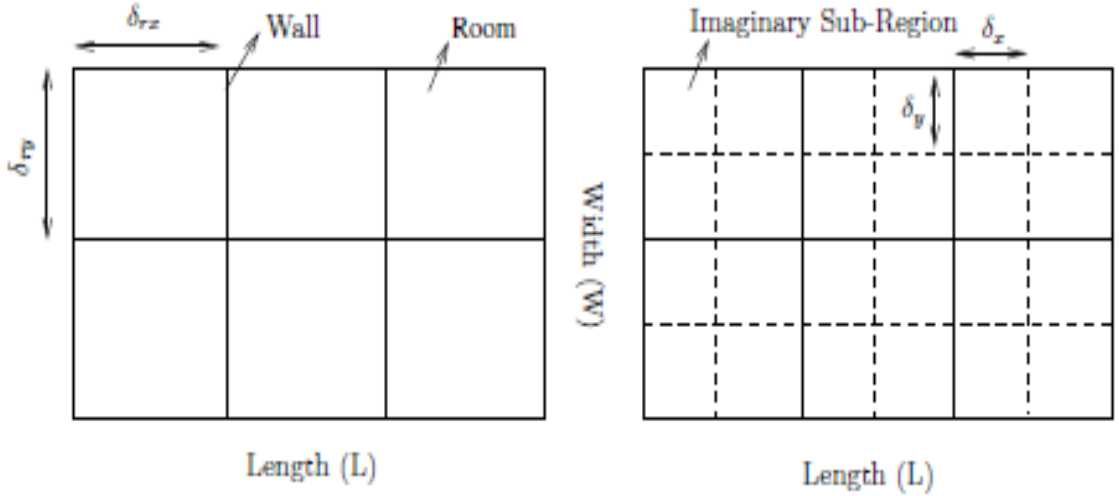
Issues in HetNet

- Co-tier interference
  -- Interference between Femtos



(A) System model and assumptions

- No cross-tier and co-tier interference.
- Height of each floor is constant
- Length and width of each room is constant
- Length and width of each sub-region is constant



(B) Proposed formulation for *Femto placement*

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- Goal: The objectives of the *Femto placement* is to find the minimum number and optimal co-ordinates of Femtos

Table: Notations in Problem Formulation

Notation	Definition
δ_{rx} *and* δ_{ry}	Length and Width of each room
γ_{ijk}	SINR inside the region ijk and γ'_{ijk} *is the reciprocal of* γ_{ijk}
p_{ijk}	UE occupant probability in the sub-region ijk
x_f, y_f *and* z_f	Femto co-ordinates
λ_{fp}	λ_{fp} be the binary variable which is 1 if Femto is placed in room ρ
π_{ijk}^{f}	π_{ijk}^{k} be the binary variable which is 1 if f^{th} Femto is serving sub-region ijk.

(C) Conversion and Approximations Applied

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- The Mixed integer non-linear programming problem is converted to Mixed integer linear programming problem by the taking the following approximations :
  - Piece-wise linear Approximation (PLAP) Model which applied while converting the distance equations from quadratic to linear expressions.
  - Log function was utilized to convert the non- linear relation between power capacity and SINR.
  - Lower and upper bound for the co-ordinates of Femto-cell are calculated to introduce linear constraints.
- The value of the path loss exponent is chosen as 3.5.
- The solution tree that we get after forming the LPP model is a complete binary tree so that usage of the branch and cut method improves the efficiency by removal of the branches.

(D) LPP MODEL AND SOLUTION

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- Objective Function: Minimize the total number of Femtos deployed.

$$\text{Min. Z} = \sum_{ijk} P_{ijk}\gamma'_{ijk}$$

(a) Femto Placement Constraints:

$$\gamma'_{ijk} \leq \gamma'_{\{min\}} \qquad (1)$$

$$z_f = \sum_{\rho_z=1}^{N} \rho_z \, \lambda_{\{f\rho\}} \qquad (2)$$

$$x_f \geq \sum_{\rho_x=1}^{N} (\rho_x - 1)\delta_{rx}\lambda_{fp} \qquad (3)$$

(D) LPP MODEL AND SOLUTION

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$$x_f \geq \sum_{\rho_x=1}^{N} \rho_x \delta_{rx} \lambda_{fp} \qquad (4)$$

$$y_f \geq \sum_{\rho_y=1}^{N} (\rho_y - 1) \delta_{ry} \lambda_{fp} \qquad (5)$$

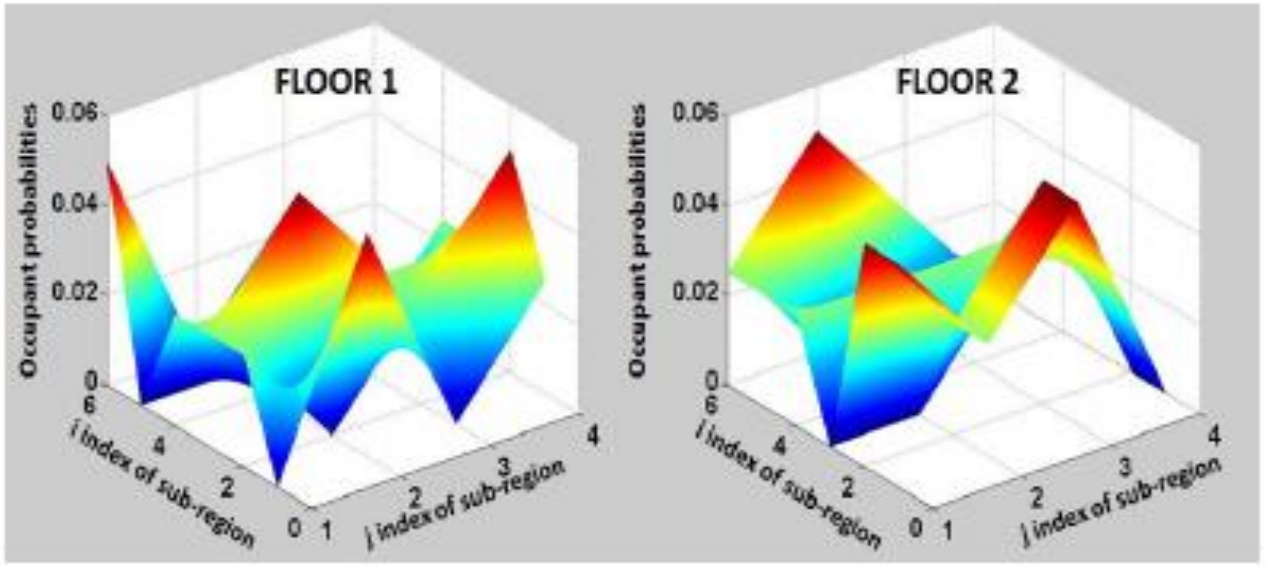
$$y_f \geq \sum_{\rho_y=1}^{N} \rho_y \delta_{ry} \lambda_{fp} \qquad (6)$$

$$\sum_{f=1}^{F} \pi_{ijk}^{f} = 1 \qquad (7)$$

Simulation Parameter

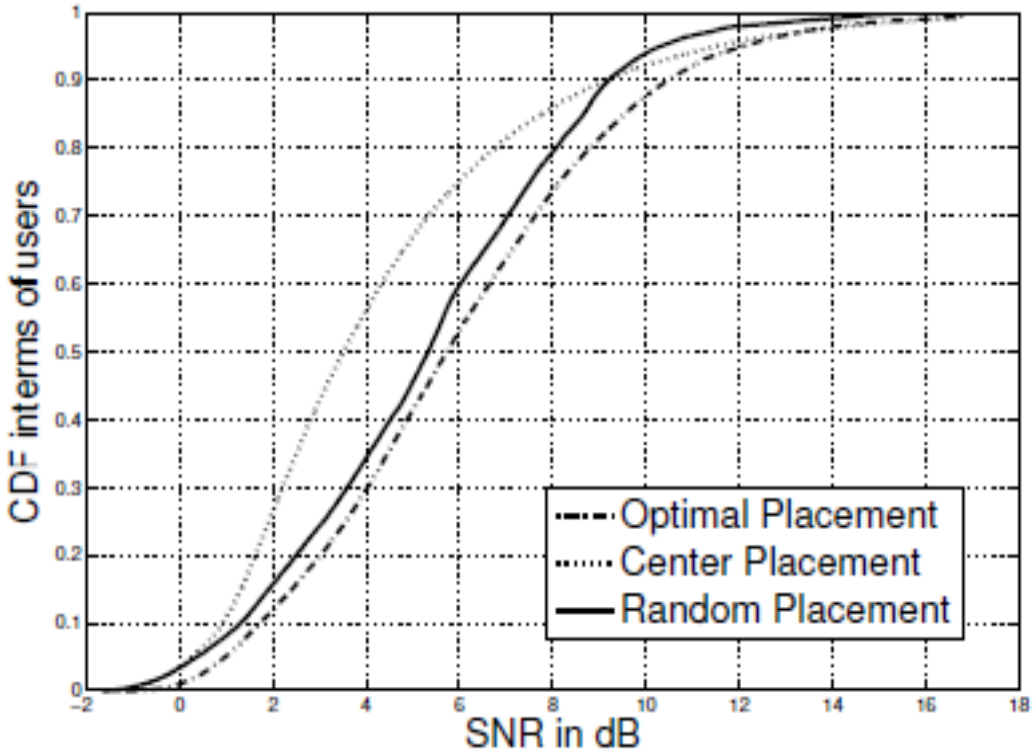
Parameters	Values
Building Dimensions	120 m X 80 m X 12m
Number of Rooms	6
Room Dimensions	40 m X 40 m X 6 m
Inner sub-region dimension	20 m X 20 m X 6 m
Number of Floor	Two
Number of Femtos	Four
Femto and Macro Power	20 and 46 dBm
Minimum SINR Guaranteed	$\gamma_{\{min\}} = -5\ dB$
Indoor path loss constant	3.5

UE occupant probability inside building and optimal co-ordinates



Femto	x_m	y_m	z_m
F1	30.0	25.22	1
F2	76.68	59.34	1
F3	43.32	50.0	2
F4	79.05	30.0	2

Variation of SINR inside the building



- The optimal placement performance is 14.41% and 35.59% better than random and center placement.

REM plot using ns-3 in Floor 1

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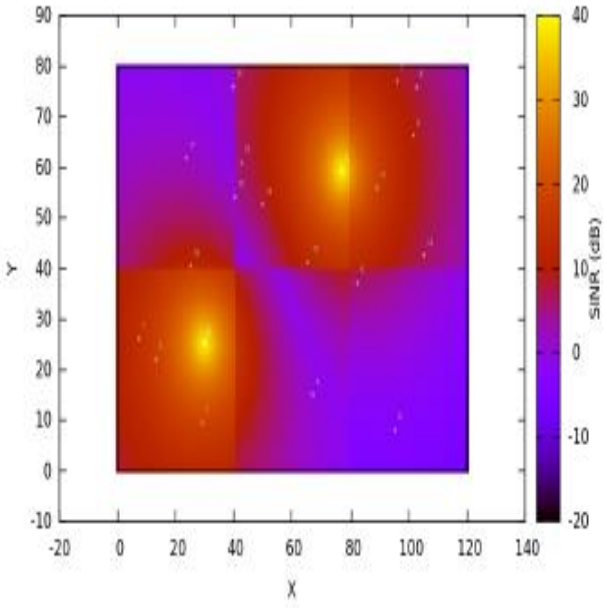
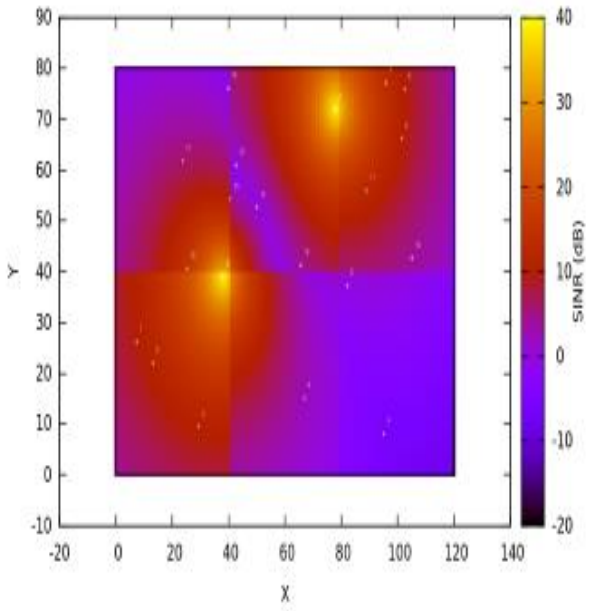
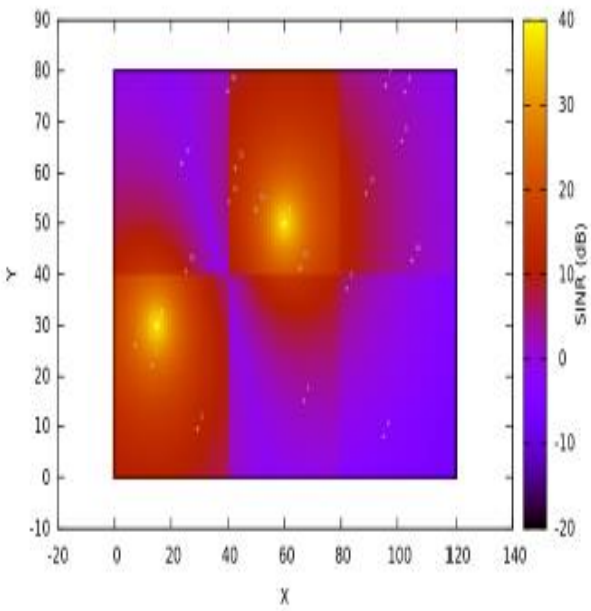


Optimal Placement



Center Placement



Random Placement

- Most of the UEs in floor one are in good vicinity to Femto coverage which indicates our optimal placement is good when compare to center and random

REM plot using ns-3 in Floor 2

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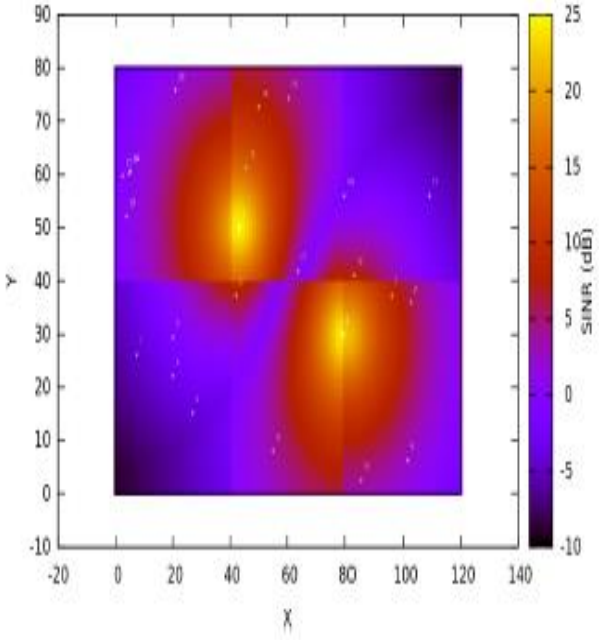
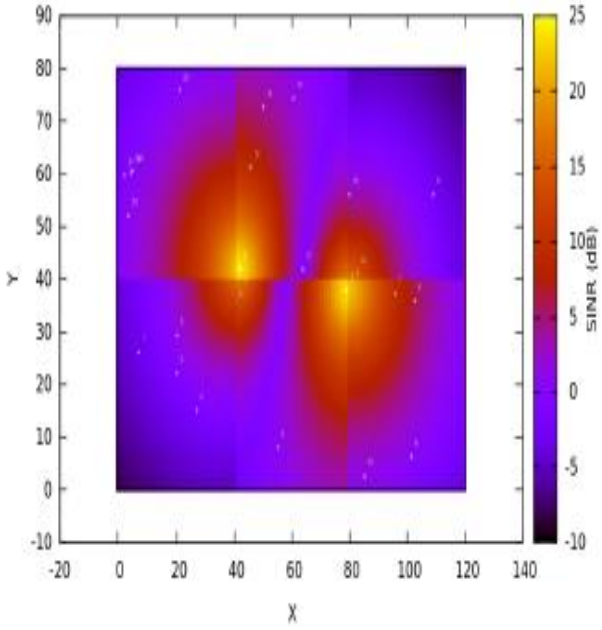
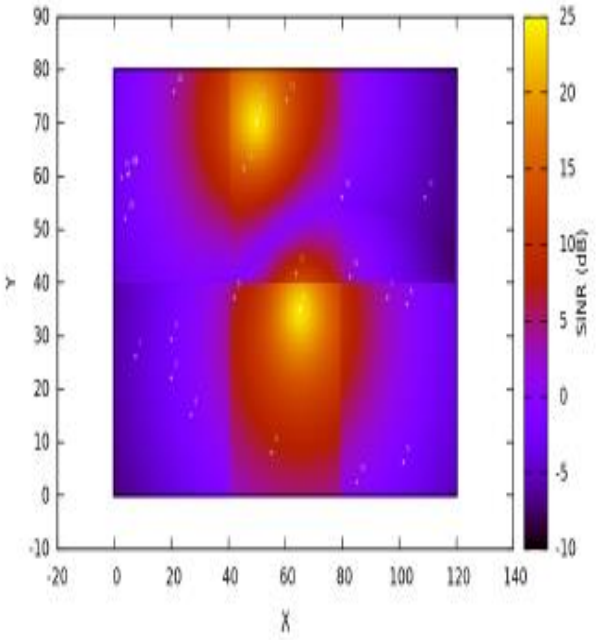


Optimal Placement



Center Placement



Random Placement

SUMMARY AND FUTURE WORK

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- In future, we intend to provide an algorithm for optimal placement for various environment considering more complex scenario involving load balancing and interference between Femtos.

ACKNOWLEDGMENTS

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QUESTIONS?