Presentation for:

# Radio Resource Management Cellular Planning Tool


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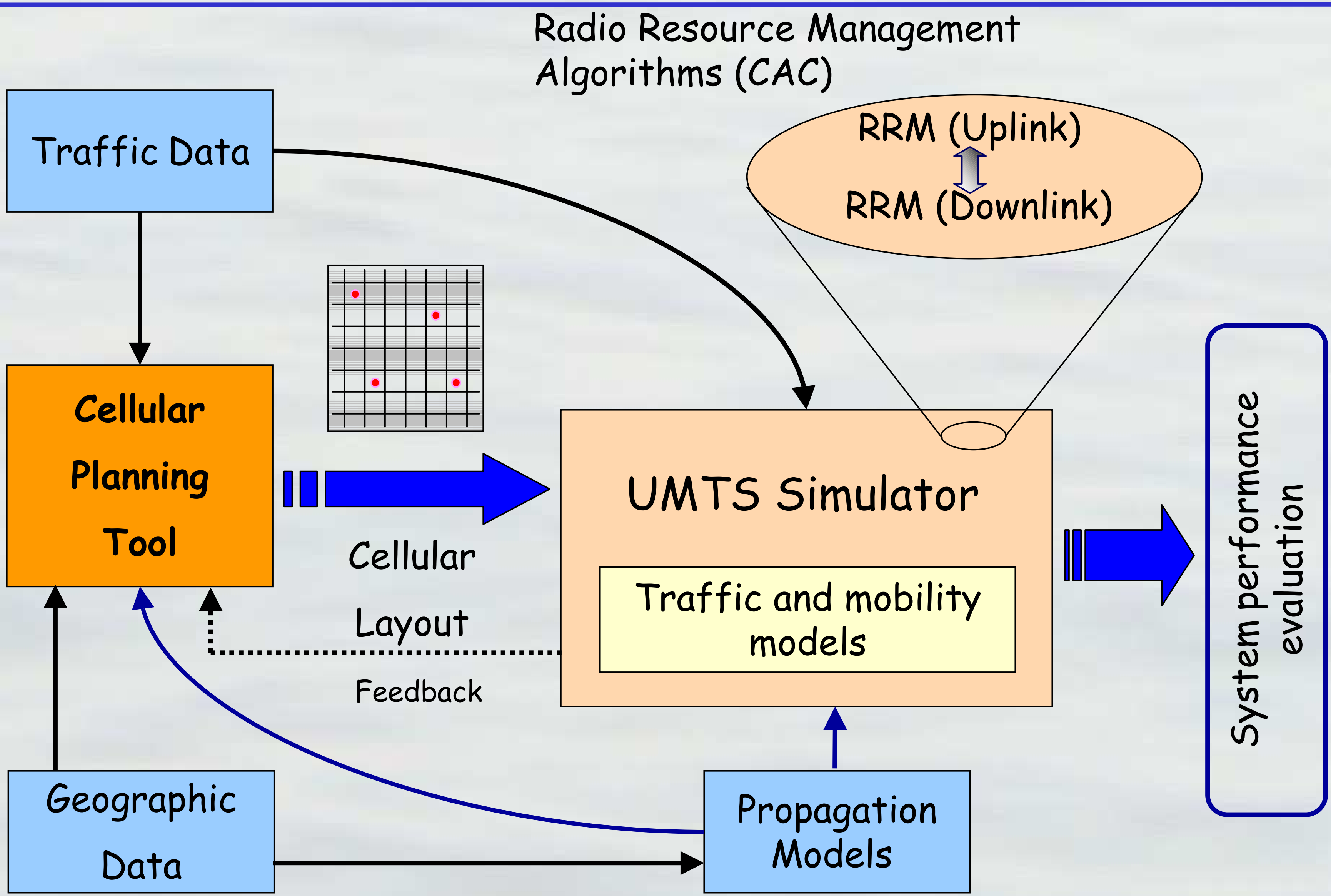
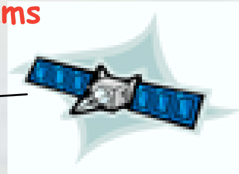
# GENERAL OVERVIEW



# CELLULAR PLANNING TOOL

**OBJECTIVE** : Localize and configurate antennas in order to ensure required service level in the target area while minimizing deployment costs.

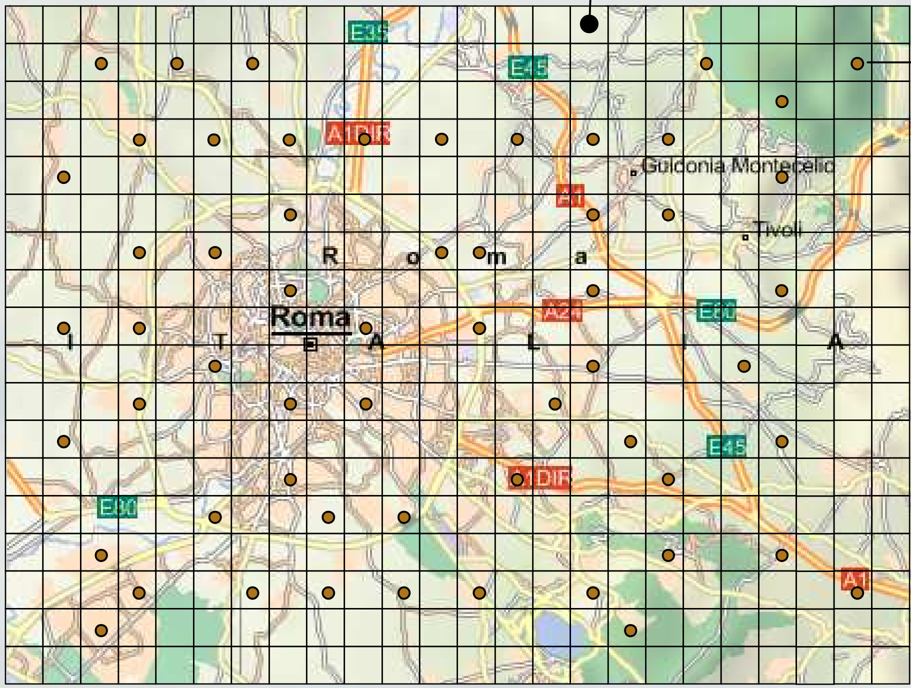
Candidate satellite beams



Test Point (TP)
- Location
- Traffic demand for each service : $T_r^s$

Set of TP : **R**

Set of services : **S**




target area

Candidate t-location (special TP)

**B** : set of candidate locations, both terrestrial and satellite

**Activation variables:**

$$y_b = \begin{cases} 1 & \text{if an antenna is activated in } b \\ 0 & \text{otherwise} \end{cases}$$

**Assignment variables:**

$$x_{rb} = \begin{cases} 1 & \text{if TP } r \text{ is assigned to } b \\ 0 & \text{otherwise} \end{cases}$$

**Power variables:**

$p_r^s \in [0, P_{MAX}]$: emitted power from mobiles located in TP $r$ and requesting service $s$

continuous varibles

Problem formulation | Constraints

## Standard facility location constraints

$$x_{rb} \leq y_b \qquad \forall r \in R \quad \forall b \in B$$

$$\sum_{b \in B} x_{rb} = 1 \qquad \forall r \in R$$

A TP can be assigned only to one active BS or satellite beam

## Link-budget constraints

$$p_r^s / l_{rb} \geq \left(\sum_{k \in S} \sum_{i \in R} v^k T_i^k p_i^k / l_{ib} + N\right) \cdot SIR^s - M \cdot (1 - x_{rb})$$

Uplink

Downlink modeling is similar

## Nearness constraints

$$x_{rb} + \sum_{k \in V(r,b)} x_{rk} \geq y_b$$

A TP is assigned to the nearest active BS or satellite beam

$V(r,b)$: Set of candidate locations closer than b to TP r (only for terrestrial sites)

Problem formulation | Objective function

**B** : set of candidate locations, both terrestrial and satellite

## Minimization of total installation cost

$$\min \sum_{b\in B} f_b \cdot y_b + \sum_{b\in B}\sum_{r\in R} c_{rb} \cdot x_{rb} + \sum_{r\in R} c_{r(|B|+1)} x_{r(|B|+1)}$$

Activation costs

Service cost

Non coverage costs

**"False station"** To account for unassingned TPs

$$\left.\begin{aligned} y_{|B|+1} &= 1 \\ f_{|B|+1} &= 0 \end{aligned}\right\} \text{no activation cost}$$

$$x_{r(|B|+1)} = \begin{cases} 1 & \text{if TP } r \text{ is not covered} \\ 0 & \text{otherwise} \end{cases}$$

- Problem: huge instances, difficult to solve exactly!

Solution algorithm | Problem analysis

If the vector of actived antenna is given → $\overline{y}$

$\overline{\mathbf{B}}$ : set of activated antennas

Assignment vector is uniquely determined (thanks to nearness constraints) → $\overline{x} = x(\overline{y})$

Only power variable must be determined → $\begin{cases} \tilde{A}p \geq N \cdot SIR \\ p_r \leq P_{MAX} \end{cases}$

**Interference system** : system of linear inequalities in the power variables

Solution algorithm | Problem analysis

## Interference system reduction

Received power variables : $\pi_b$ is the power received at BS b, emitted by a TP assigned to it

$$\tilde{A}p \geq N \cdot SIR$$

$$\dim : |R| \times |R|$$

$$\sum_{b \in \overline{B}} a_{rb} \cdot \pi_b = N \cdot SIR \quad \forall b \in \overline{B}$$

$$\dim : |\overline{B}| \times |\overline{B}|$$

**Remark** $|\overline{B}| << |R|$ The reduced system can be solved very eficently

Solution algorithm | Solution algorithm

**LOCAL SEARCH** → To solve very efficently large istances

1. Start with a current solution $(\bar{y}, \bar{x}, \bar{p})$

2. Select a proper neighborhood of the solution (exchange) $N(\bar{y}, \bar{x}, \bar{p})$

3. Find the best solution in the neighborhood $(y^*, x^*, p^*)$

4. Update current solution and go to 2