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UNIVERSITÀ DELLA CALABRIA

DIMES - Dipartimento di INGEGNERIA INFORMATICA MODELLISTICA, ELETTRONICA E SISTEMISTICA

Mobility Prediction in Wireless Cellular Networks for the Optimization of Call Admission Control Schemes

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SPEAKER:
Peppino Fazio

7th May 2014 – ENG105 – Session CN7

Introduction

Wireless Comm.

Passive Reservations

Bandwidth Prediction

Simulation Analysis

Conclusions

PRESENTATION LAYOUT

- **Wireless communications and mobility**
- **Passive reservations protocol and concept**
- **Prediction and Multiplexing for CAC**
- **Simulation results analysis**
- **Conclusions**

Introduction
Wireless Comm.
Passive Reservations
Bandwidth Prediction
Simulation Analysis
Conclusions

PROPOSAL SUMMARY

- A statistical predictive Call Admission Control (CAC) scheme is proposed;

- Introduction of analytical modeling for the design of reservations multiplexing;

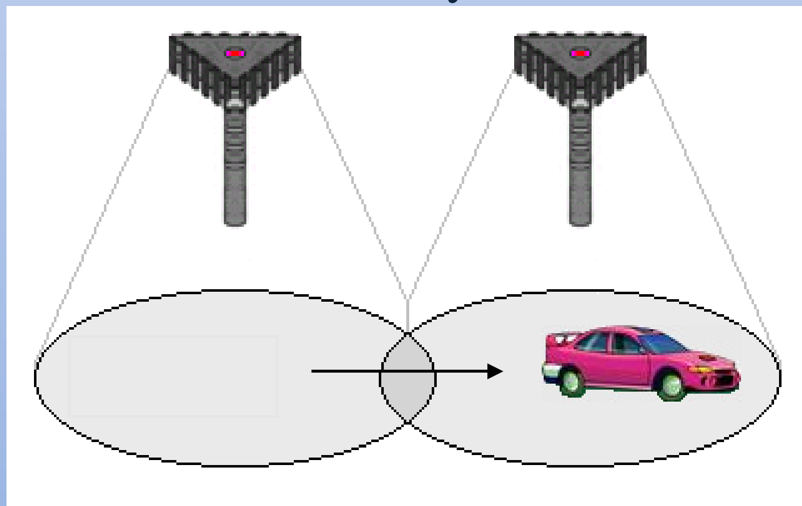
- Evaluation of the introduced enhancements in terms of Admitted flows, CBP, CDP and System Utilization.

Introduction
Wireless Comm.
Passive Reservations
Modeling and proposal
Simulation Analysis
Conclusions

WIRELESS COMMUNICATIONS

-Wireless Networks are proving to be the next major evolution of technology for businesses;

-Independently from the considered wireless technology, fading is highly-varying with time/space and mobility results in many hand-in/hand-out events among the visited cells into the system.



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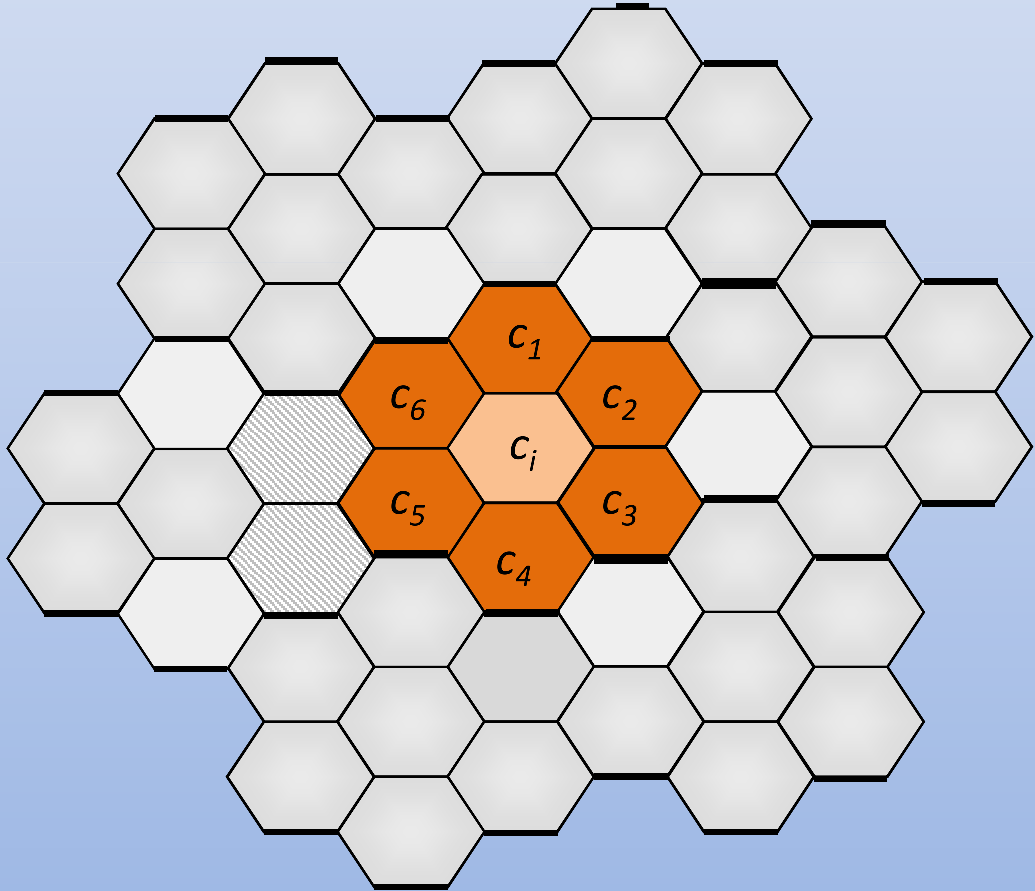
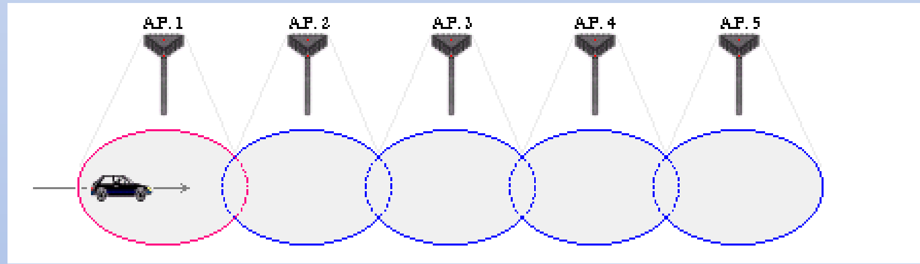
WIRELESS COMMUNICATIONS



Typical cellular networks adopt clustered coverage structure, so users can move and make different hand-over operations.

MRSVP PASSIVE RESERVATIONS

-MRSVP (Mobile ReSerVation Protocol) [1], [2], [6] was born as an extension of RSVP for the mobility support in wireless networks;
-We considered the passive-reservations feature of the MRSVP:



-When users make service requests on the current cell (active), the resources are reserved also on the remote locations (passive);

-We are interested on discovering what cells users will visit during their flows, so the system can a-priori know if a new request can be admitted.

Introduction

Wireless Comm.

Passive Reservations

Modeling and proposal

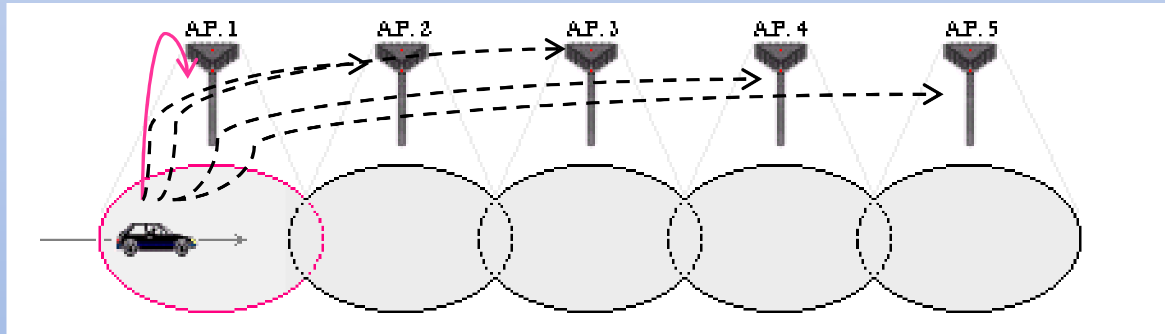
Simulation Analysis

Conclusions

MRSVP PASSIVE RESERVATIONS

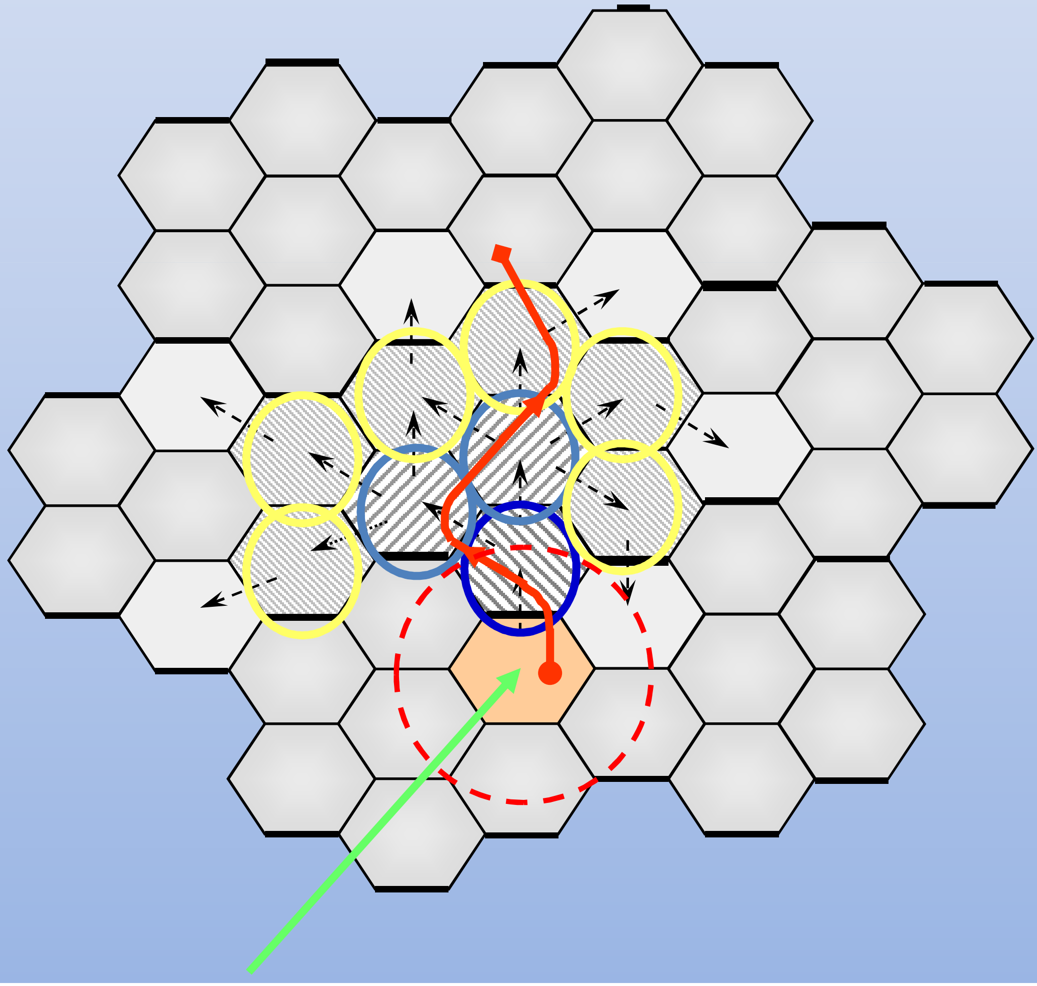
-An Active-RESV message is sent to the current coverage cell;

-Passive-RESV messages are sent to the remote cells:



Introduction
Wireless Comm.
Passive Reservations
Modeling and proposal
Simulation Analysis
Conclusions

MRSVP PASSIVE RESERVATIONS



In a real 2D scenario different issues should be faced:

1) How many cells a user will visit?

2) What cells a user will probably visit?

3) **How many reservations can be managed in a cell**?

Introduction
Wireless Comm.
Passive Reservations
Modeling and proposal
Simulation Analysis
Conclusions

MRSVP PASSIVE RESERVATIONS

-In our previous works [1], [2], [4], [13], we faced some issues about Cell Stay Time (CST) evaluation and mobility prediction;

-In literature many authors treated the problem of CST determination [12], cell prediction [7], [8], [9], CDP/CBP optimization and QoS;

-In this work, by the **IAM-CAC**, we:

a) Propose a statistical CAC scheme, that is independent on the particular predictor;
b) Exploit a multiplexing passive reservation policy, in order to enhance system utilization;
c) Implement a distributed approach, dedicated for each single cell of the system.

Introduction

Wireless Comm.

Passive Reservations

Modeling and proposal

Simulation Analysis

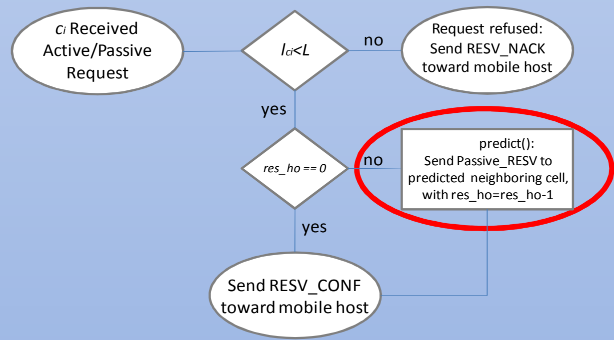
Conclusions

MODELING AND PROPOSAL

Given a particular geographical region, it is possible to cover it by a set of cells $C=\{c_1,\ldots,c_c\}$ with radius R.

Let us suppose that a service request is made in a cell c_i;

Then a MRSVP session starts:



Introduction
Wireless Comm.
Passive Reservations
Modeling and proposal
Simulation Analysis
Conclusions

MODELING AND PROPOSAL

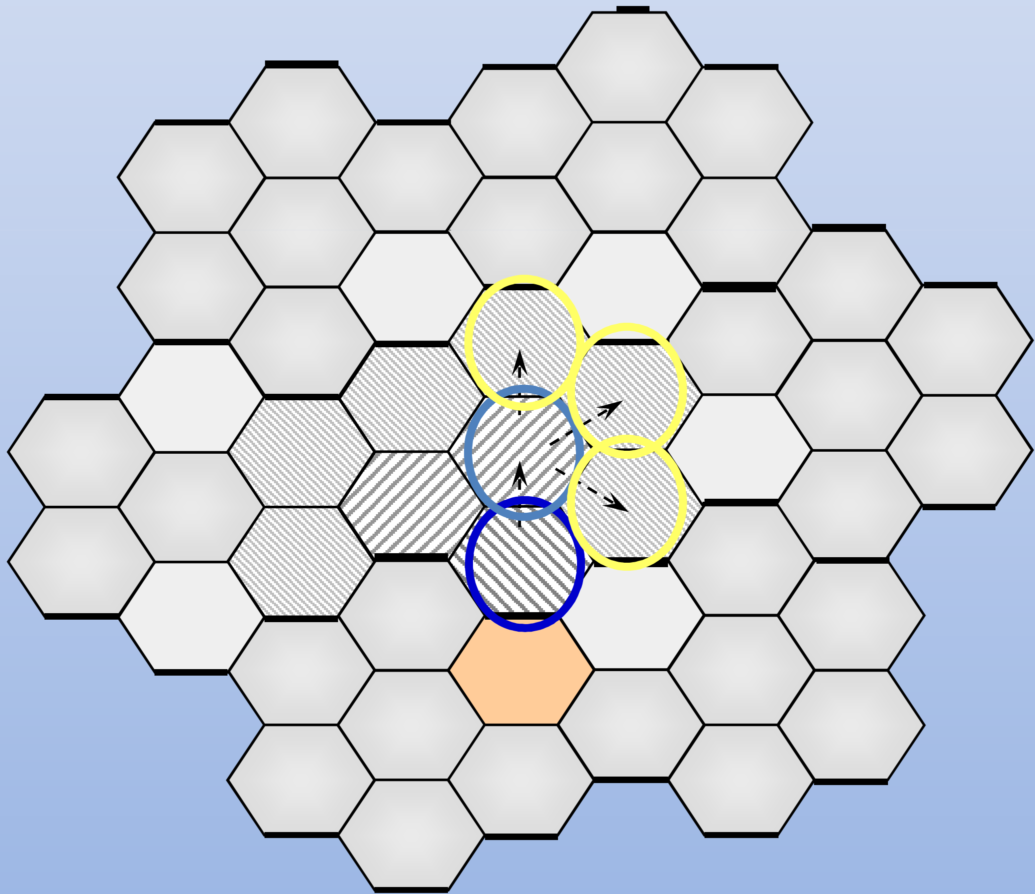
As shown in previous works, a predictor p_i is associated to each cell c_i:

p_i can consist of, for example, a Markov chain, a Neural Network or other conventional/ unconventional tool.

We are not interested to the particular structure of p_i, but to its output: each p_i predicts **the most probable cells that will be visited after the hand-over**.

Introduction
Wireless Comm.
Passive Reservations
Modeling and proposal
Simulation Analysis
Conclusions

MODELING AND PROPOSAL



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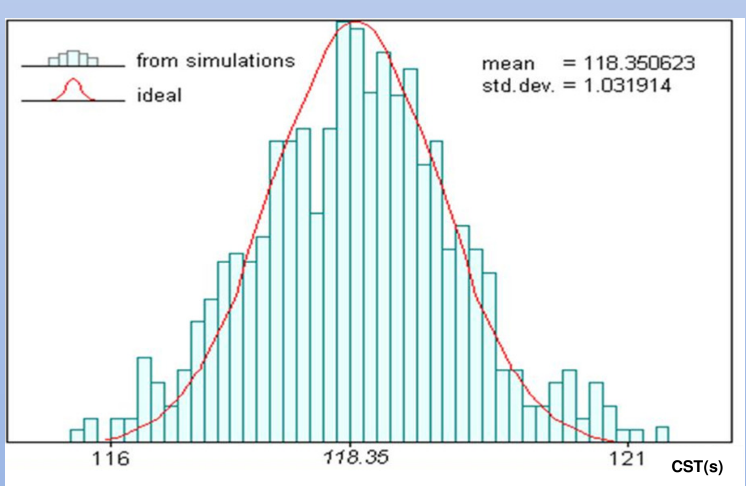
Introduction
Wireless Comm.
Passive Reservations
Modeling and proposal
Simulation Analysis
Conclusions

MODELING AND PROPOSAL

The proposed IAM-CAC scheme is also based on time-multiplexing concept so, first of all, it is necessary to take into account how the CST can be described.
Running different simulations, the trend of CST samples has been observed for each cell, so it is possible to obtain a distribution of it.

In particular it follows a Gaussian shape (R=250m in the figure).



So the general expression of the CST can be written as:

$$f_{X_{CST}}(x) = \frac{1}{\sqrt{2\pi}\sigma_{CST}} e^{-\frac{(x-\mu_{CST})^2}{2\sigma_{CST}^2}}$$

Introduction
Wireless Comm.
Passive Reservations
Modeling and proposal
Simulation Analysis
Conclusions

MODELING AND PROPOSAL

So, we can say that CST probability density function (pdf) for cell c_l follows a Gaussian trend:

$$\boxed{pdf_{l\,CST} \cong G(\mu_l, \sigma_l)}$$

Obviously it is verified for each cell of the network and the values of μ_l and σ_l can be obtained through some dedicated simulations.

Let $\text{handoff}^u_{in}(h)$ and $\text{handoff}^u_{out}(h)$ indicate the predicted times of arrival and departure to/from a cell of user *u* for the *h-th* hand-off event respectively. Then, given a pdf of CST, it can be written that:

$$handoff^{u}{}_{in}(h+1) = handoff^{u}{}_{in}(0) + \sum_{m=1}^{h} \overline{handoff}_{lm}(m)$$

Introduction

Wireless Comm.

Passive Reservations

Modeling and proposal

Simulation Analysis

Conclusions

MODELING AND PROPOSAL

$$handoff^{u}{}_{in}(h+1) = handoff^{u}{}_{in}(0) + \sum_{m=1}^{h} \overline{handoff}_{lm}(m)$$

where $handoff^{u}{}_{in}(0)$ is the time at which the user made the active reservation and $handoff_{lm}(m)$ is a CST realization for the predicted cell c_{lm} for the m-th hand-over.

So, given MH *u* and the predicted cell c_m, it is possible to obtain the duration of each passive request for the *h-th* hand-off as:

$$delta^{u}{}_{in}(h) = handoff^{u}{}_{out-m}(h) - handoff^{u}{}_{in-m}(h)$$

If users u and v are reserving passive bandwidth in cell m for h-th and k-th hand-over respectively, they can be **multiplexed** on the same slot if their reservation times have an empty intersection:

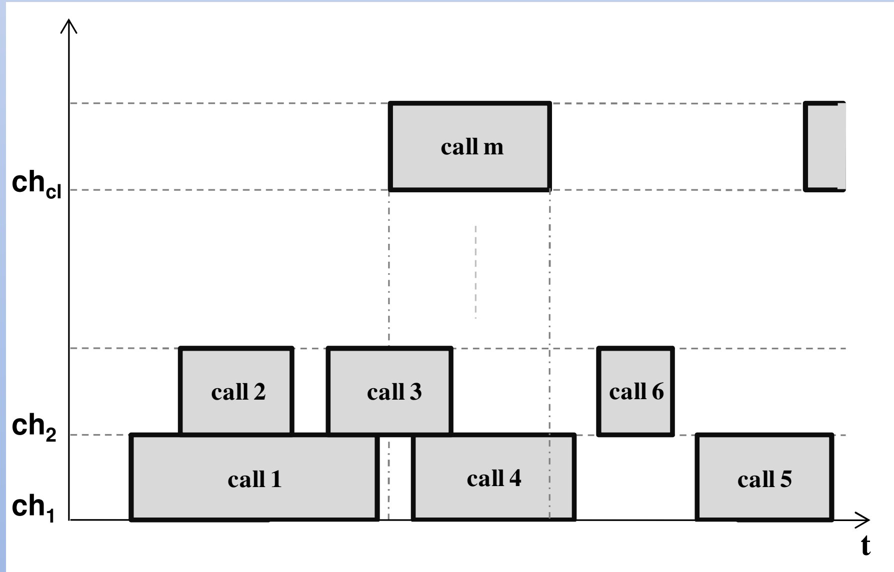
$$delta^{u}{}_{m}(h) \cap delta^{v}{}_{m}(k) = \varnothing$$

Introduction
Wireless Comm.
Passive Reservations
Modeling and proposal
Simulation Analysis
Conclusions

MODELING AND PROPOSAL

$$delta^{u}{}_{m}(h) \cap delta^{v}{}_{m}(k) = \varnothing$$

That is to say two requests can be admitted into a cell on the same channel if their time reservation intersection is null.



Each cell of the considered cellular system has a certain number of available transmission channels; so, we can say that each coverage cell $c_l \in C$ has a capacity set of channels $B_l = \{ch_1, ..., ch_{cl}\}$ (in our approach, without loss of generality, $B_l = B$, $\forall c_l \in C$).

Introduction
Wireless Comm.
Passive Reservations
Modeling and proposal
Simulation Analysis
Conclusions

MODELING AND PROPOSAL

At this point, after the application of MRSVP and the prediction algorithm for the request of mobile host *u*, the predicted path (in terms of cell sequence) PATH is obtained, with ||PATH||=k:

$$PATH^{u} = \{ \mathrm{c}_{0}^{\mathrm{u}}, \mathrm{c}_{1}^{\mathrm{u}}, \mathrm{c}_{2}^{\mathrm{u}}, \ldots, \mathrm{c}_{\mathrm{k-1}}^{\mathrm{u}} \}$$

On the basis of the multiplexing approach explained in the previous slide, for each c^{u}_{l} it is possible to know the predicted hand-in and hand-out times.

The core idea of the IAM-CAC is now illustrated.

Introduction
Wireless Comm.
Passive Reservations
Modeling and proposal
Simulation Analysis
Conclusions

MODELING AND PROPOSAL

Since the prediction algorithm gives as output the probability of reaching each $c^u{}_l \in PATH^u$, then it is possible to define the Reaching PROBability (RPROB) for $c^u{}_l$:

$$RPROB = p_{01} \cdot p_{12} \cdot \ldots \cdot p_{(l-1)l} = \prod_{ij,i \neq j}^{j=l} \mathrm{p}_{\mathrm{ij}}$$

where p_{ij} represents the probability of going from cell $c^u{}_i$ to cell $c^u{}_j$ ($c^u{}_i$ and $c^u{}_j \in PATH^u$).

A new request (active or passive) of user *u* is admitted into cell c_l if and only if:

$$\boxed{\mathrm{RPROB} \geq p_{min} \text{ AND } \exists ch_i \in B_l \,/\, delta^u{}_l(h) \cap delta^v{}_l(k) = \varnothing \;\forall\, v \neq u,}$$

where p_{min} is a threshold.

Introduction

Wireless Comm.

Passive Reservations

Bandwidth Prediction

Simulation Analysis

Conclusions

SIMULATION ANALYSIS

Simulation model and parameters

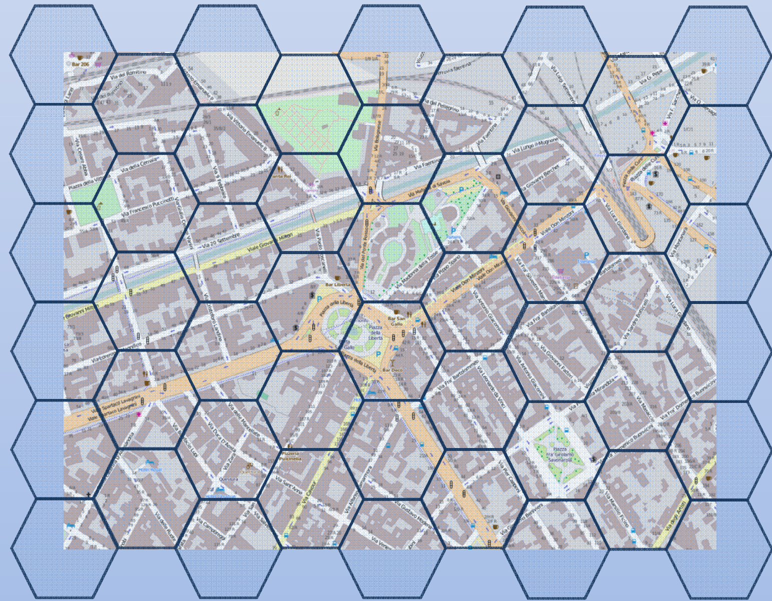
- A coverage extension of 1Km^2 and real paths of Florence city have been considered through the C4R mobility simulator;

-All the cells have the same coverage radius *R* and the same channel capacity B_1=30;

-Training campaign of 500 runs with 500 mobile nodes for each run;

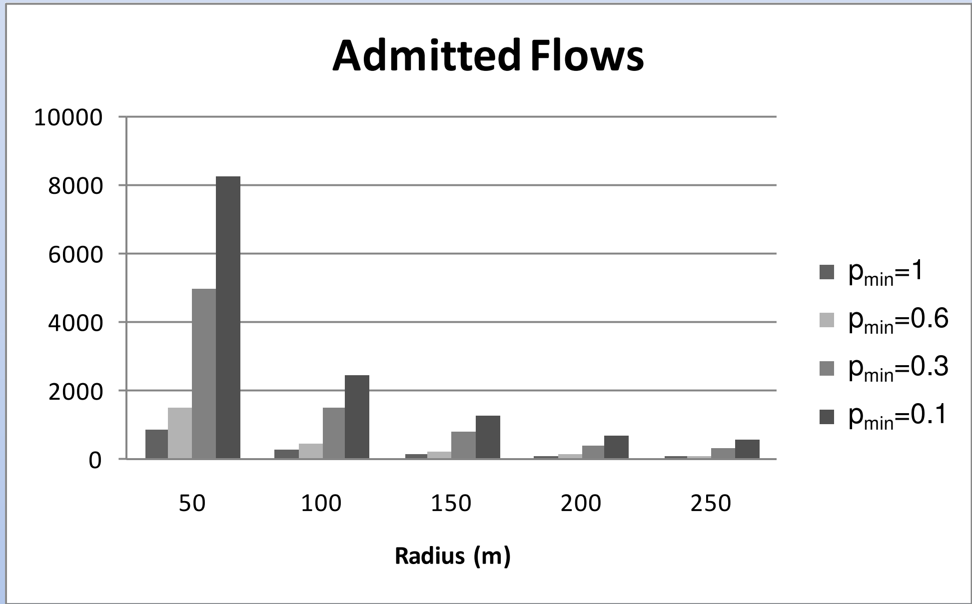
- An arrival rate of 2 calls/s has been considered.

SIMULATED MAP



SIMULATION ANALYSIS

Introduction
Wireless Comm.
Passive Reservations
Bandwidth Prediction
Simulation Analysis
Conclusions



On the left, it is possible to observe the trend of the average number of admitted flows for different values of R.

There is a decreasing trend for higher R, since each cell covers a bigger area but the number of channels remain the same.

Lower values of p_{min} bring the system to admit more requests.

Introduction

Wireless Comm.

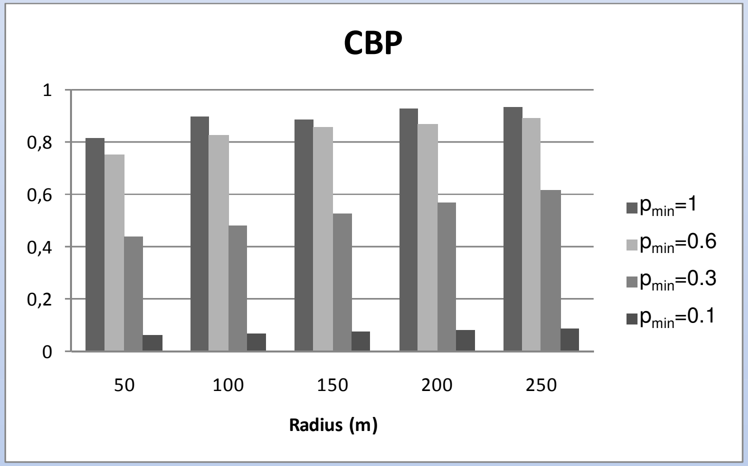
Passive Reservations

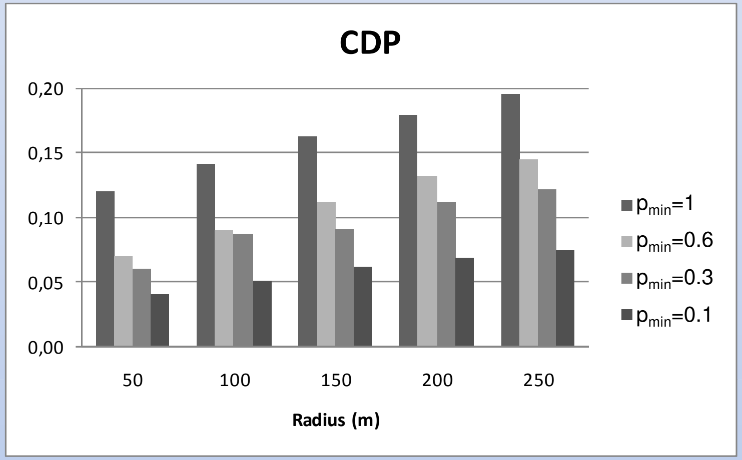
Bandwidth Prediction

Simulation Analysis

Conclusions

SIMULATION ANALYSIS





The figures (on the left and on the right) show the average trend of CBP and CDP respectively.

Both parameters have a decreasing trend for lower p_{min} values: in the case of CBP, there is a higher chance to be admitted into the system, since the values of RPROB will be higher than the threshold; in the CDP there will be more passive reservation (more passive requests will be considered) so a lower probability to find scarce resources.

For higher R values, in both cases the trend is increasing: each cell will consider a bigger coverage area, but the number of available channel remains the same (lower probability of finding a free slot for multiplexing). For CDP a lower number of passive reservation can be made, with a higher probability of finding scarce resource during handover.

SIMULATION ANALYSIS

Introduction

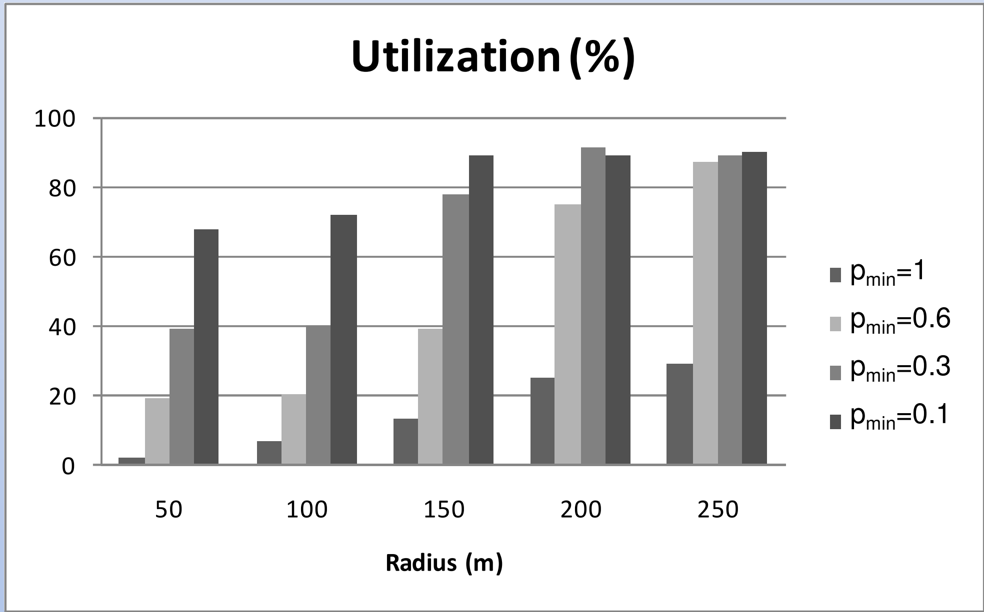
Wireless Comm.

Passive Reservations

Bandwidth Prediction

Simulation Analysis

Conclusions



On the left, network utilization is shown (it is evaluated as the average ratio of the used channels and the available ones); the average is evaluated on time and on the number of system cells.

For higher coverage radius, the network reaches the saturation point, because the number of total available channels decreases, while the rate of call requests remains the same;

Lower values of p_{min} give the opportunity of accepting more requests.

Introduction

Wireless Comm.

Passive Reservations

Bandwidth Prediction

Simulation Analysis

Conclusions

CONCLUSIONS

-In this paper a new CAC scheme for cellular networks has been shown,

- It is based on an in-advance reservation scheme that decides whether a new connection can be accepted into the system, with the main aim of maximizing bandwidth utilization while avoiding quality degradations;

- The main characteristic is the independence from the way the future visited cells are predicted and from the cellular technology.

-The proposal is called IAM-CAC and it is based on a threshold approach.

-The paper show how for values equal or lower than 0.6, it performs well in terms of CBP/CDP, number of admitted flows and system utilization.

THANKS FOR YOUR ATTENTION!