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# Fuzzy Decision Priority Scheme for Handovers In Low Earth Orbit Mobile Satellite Networks.

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**Abstract:** A queuing strategy based on fuzzy logic is proposed for mobile satellite networks, considering both durations and maximum queuing times of queued calls. Results obtained show that the proposed scheme improves the average duration of calls forced to termination due to unsuccessful handovers.

**Keywords:** LEO mobile satellite networks, handover, fuzzy logic.

## 1. Introduction:

The corporation of low earth orbit (LEO) satellites into universal mobile telecommunication systems presents several advantages: relaxation of constraints on the link budget, low power hand held mobile terminals, global earth coverage with smaller cells [1] [2].

A significant problem faced in low earth orbit mobile satellite systems LEO-MSSs is handover; when an active mobile subscriber MS goes out from a cell and enters an adjacent one, a new channel must be automatically assigned to the call in order to avoid forced termination. If there is no free channel in the destination cell 'transit cell', the call is lost. A call dropping due to an unsuccessful handover is less desirable, from the MS point of view, than the blocking of a new call attempt [3], that is why, and in order to reduce the probability that a call in progress is lost, the overlap area between adjacent cells is used to queue handover requests, since in this region an active MS can be served by both of the two cells. Requests are queued until being served, but if a call reaches the limit of the overlap area without being handed over, the request is rejected and the handover procedure fails.

In LEO MSS's, inter beam handover requests are extremely frequent during call life time, one could expect that a call experiences a handover request every one minute or even less[4].

Depending on the service order for the queued handover requests several handover policies management techniques privileging handover service at the expense of new arrival, were proposed in order to achieve better performance such as [4]-[10]. Each strategy considers a ranking criteria parameter to queue calls waiting for a free channel to be handed over toward their transit cells.

In this paper a strategy based on fuzzy logic is proposed, it considers in addition of maximum queuing times, durations of queued calls as ranking parameters. If a significant number of proposed strategies were based on fuzzy logic, name [11]-[14], not any of them, to our knowledge, consider duration of a queued call as an eventual ranking parameter.

## 2. Mobility Model:

The mobility model used in this paper is the iridium one which consists of 66 satellites equally distributed in six near polar circular orbits at about 780 km of altitude with ground-track speed  $V_{trk} = 26\ 600\ km/h$ . The coverage area has been assumed divided into cells and each cell is illuminated by an antenna spot-beam from a satellite. Cells are hexagonal shaped with circular footprints. Due to the high value of the satellite ground-track speed, the earth rotation and the user speed are neglected [15]. The direction of the MS is assumed to be the inverse of the satellite direction and orthogonal to the side of cells as it is shown in Fig. 1. The user mobility is characterized by the parameter  $\alpha$ , defined as:

$$\alpha = \frac{\sqrt{3}R}{V_{trk}T_m}. \quad 1$$

$R$  and  $T_m$  are the hexagonal cell side and the average call duration respectively. In the Iridium case  $\alpha \approx 0.27$ .

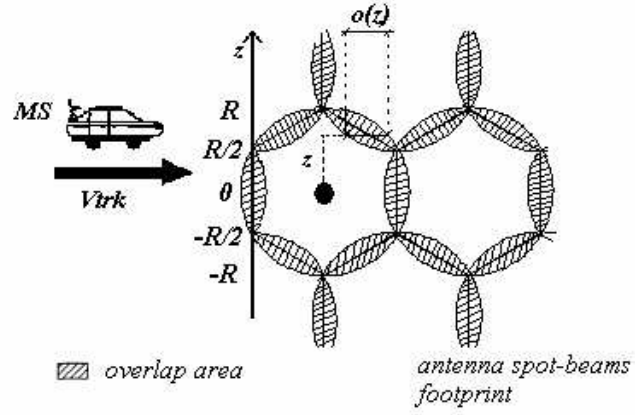


Fig. 1 Mobility model assumption

### 3. Fuzzy Decision Priority Scheme:

The strategy proposed here is based on fuzzy logic. It consider two fuzzy sub sets belonging to the set of queued calls that are "*queued calls with short durations*", and "*queued requests with short maximum queuing time*". These two sub sets are defining by the following membership functions respectively:

$$F_{sh-d}(t) = \exp(-d/T_m). \quad d: \text{duration of a call.} \quad 2$$

$$F_{sh-tq}(t_{qmax}) = 1 - \frac{t_{qmax}}{T_{qmx}}. \quad t_{qmax}: \text{maximum queuing time for a queued call.} \quad 3$$

The highest value of maximum queuing times  $T_{qmx}$  is obtained from Fig.2 which represents the variation of maximum queuing time  $t_{qmax}$  according to  $z$  in the considered mobility model, given by[4]:

$$t_{qmax} = o(z) / V_{sat}. \quad 4$$

$o(z)$  is the distance crossed by an MS with offset  $z$  in the overlap area:

$$o(z) = \begin{cases} 2\sqrt{R^2 - z^2} - \sqrt{3}R & \text{if } |z| \leq R/2 \\ \sqrt{R^2 - z^2} - \frac{\sqrt{3}}{2}R + \sqrt{R^2 - \left(|z| - \frac{3}{2}R\right)^2} & \text{if } R \geq |z| > \frac{R}{2} \end{cases} \quad 5$$

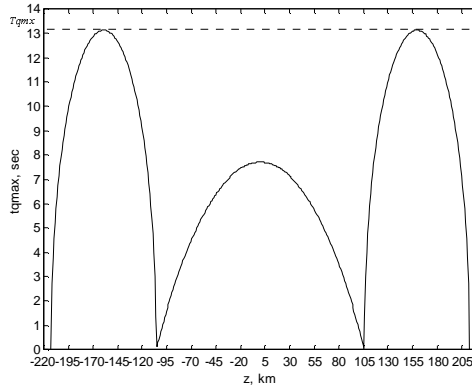


Fig. 2 Maximum queuing time according to  $z$ .

The aim researched is to consider that a call entering the queue with a short maximum queuing time and a short duration is an urgent case and must have the priority. The fuzzy sub set  $C_{sh-dt} \equiv$  "calls with short duration and short maximum queuing time" is defined by its membership function,  $F_{sh-dt} = F_{sh-d} \cap F_{sh-tq}$ .

The fuzzy *AND*  $\cap$  is the minimum operator [16]. Therefore calls are arranged in queue according to the grad of their membership in the fuzzy sub set  $C_{sh-dt}$  in a descending order as explain it examples in table .1.

Position in queue	$t_{qma} \text{ sec}_x$	$F_{sh-tq}$	$d \text{ sec}$	$F_{sh-d}$	$F_{sh-dt}$
first	3.3624	0.7441	3.3890	0.9813	0.7441
second	4.5374	0.6547	200.5629	0.3282	0.3282
third	3.2654	0.7515	310.4587	0.1782	0.1782
fourth	13.0978	0.0032	227.0541	0.2833	0.0032

Table 1 Example of FDPS queuing strategy.

#### 4. Simulation:

The following assumptions have been made in simulation:

- The dimension of the network used in the simulation is the common choice in literature, 7 cells per side total 49 folded onto its self [17].
- The average call duration is  $T_m = 180$  sec.
- Belt of interfering cells is formed by two tiers of cells.
- A number of 70 channels is available to the system Dynamic channel allocation DCA is used.
- Call arrival process is Poisson independent from cell to cell with average call arrival rate per cell equal to  $\lambda$ .
- Uniform traffic model is assumed.
- An infinite queue capacity is assumed.

Performance quality of service QOS parameters: blocking probability of new call attempts  $P_{b1}$ , handover failure probability  $P_{b2}$ , and unsuccessful call probability  $P_{ns}$  for both LUI and FDPS are presented in Fig.3. Results obtained show that LUI achieves better performance than FDPS.

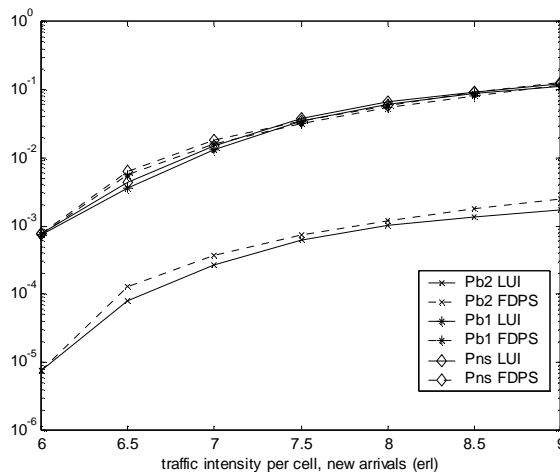


Fig.3 Performance QOS parameters using DCA for LUI and FDPS (IRIDIUM case)

In order to know if the proposed scheme has any effect on the behavior of the network, durations of calls forced to termination are collected during the simulation for each value of traffic intensity. A certain increase in the average length of dropped calls is remarked for FDPS.

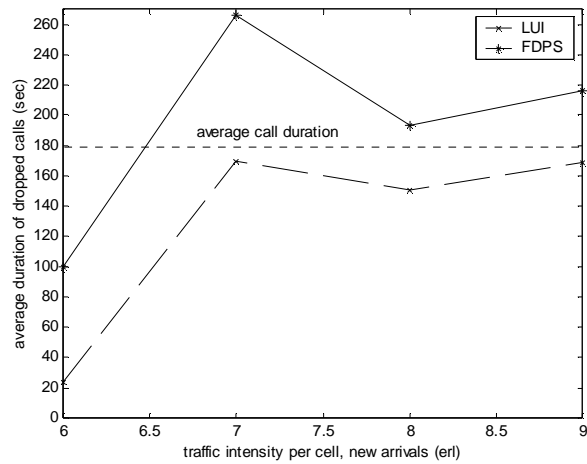


Fig.4 Average duration of dropped calls for LUI and FDPS.

Fig.5 presents the variation of this last according to the traffic intensity for the two schemes LUI and FDPS: in the first case, for different values of traffic intensity calls are forced to termination with an average length that is less than the average call duration. While in the second case, and except for traffic intensity equal to 6erl, the average length of dropped calls surpasses  $T_m$ .

## 5. Conclusion:

This paper has proposed a new queuing strategy based on fuzzy logic, the fuzzy decision priority scheme FDPS, which considers for the first time, to our knowledge, duration of queued call as a ranking parameter.

While comparing FDPS with the LUI queuing scheme previously presented in the literature, we note that this last still achieves better performance in terms of blocking probability, but an improve on average length of calls forced to termination is observed in the proposed strategy.

It will be attractive for LEO MSSs to achieve both good performance and improved average length of calls dropped due to an unsuccessful handover.

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