Fuzzy inference used for admission control in (E)GPRS

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Motivation

- For my PhD (2000-2005) I studied resource allocation for (E)GPRS
- Resource allocation means:
  - Admission control (AC): which users to admit for data transmission/reception
  - Transmission control (TC), i.e. scheduling channels to admitted users
- TC needs quite efficient, but fast algorithms => not needed AI techniques
- The problem of AC in (E)GPRS is much more complex => AI techniques could be useful !

Motivation (cnt'd)

- AC algorithms for GPRS have been more complex than the AC algorithms used at that time:
  - Like AC alg for ATM networks, in GPRS we have different types of traffic, but in ATM the users are not mobile
  - Like AC for GSM networks, complexity comes from users' mobility, but in GSM there is only one type of traffic: voice, i.e., no contradictory QoS requirements for users
- For a problem of such complexity AI could be used
- However, in telecom the "tradition" was to use probabilistic models
- This makes sense, since the uncertainty is rather stochastic than fuzzy !
- But, the stochastic models used successfully for other types of networks became too complex for GPRS !
  - Needs some explanations !

Motivation: the stochastic models

- Typically either queueing models, or Markov models have been used (for fixed or mobile telephony)
- Both need ``nice'' (i.e. exponential) probability distribution functions (Poisson processes)
- The events in fixed telephony or even GSM obey such distributions
- But the data traffic does not in general !
- Some researchers tried to model the ON-OFF type traffic specific to data (e.g. to WWW) using Markov Modulated Poisson Processes
  - quite similar to decomposing a rectangular signal into sums of sine or cosine signals, on-off was decomposed into Poisson Processes with different rates
  - The resulted mathematical models were extremely complex
  - So complex that new mathematical techniques have been used for solving them
- Or, in order to be able to solve the resulted models, the researchers made some assumptions regarding the events or traffic types that are not valid !

Motivation

- Fuzzy logic has been used for AC in ATM networks, so why not using it for GPRS
- Still, I had some doubts if FL can deal with stochastic uncertainty !
- At that time one of my supervisors was against using FL in telecom !
- I came closer to a solution when I read two papers dealing with AC in GPRS that used different AC policies for different regions
- Regions means either different network loads, or numbers of users from each QoS class
- Some papers with FL used in ATM used FL to extend thresholds

Thresholds

- Stuckmann et al used different AC policies for different network load:
  - For **low** network load admit all users
  - For **medium** netw load admit all high priority users, but admit only conditionally low priority users
  - For **high** netw load admit only high priority and drop low priority users, if needed !
  - The thresholds that separate low-medium and medium-high network load simply assigned (i.e. guessed) by authors, with no explanation !
- Kim et al
  - computed (with quite complex math) how many users from each traffic class can be admitted in order to meet the QoS
  - Here the thresholds were computed with big effort, but if the input data change (network settings), they have to recompute !

FL

- The terms low, medium, high network load sound very fuzzy !
- So, why not replace the sharp thresholds that separate different regions with fuzzy terms
- In this way the thresholds become less important, so no need to compute them
- Also, no need to change them when the settings change
- Advantage for network operators: use experience, expressed in IF-THEN rules, instead of complex math (eg queueing, Markov models, etc)
- Then, it was only a technical problem: to find a parameter that will be controlled by the FLC
- I managed to expressed the network load as to be proportional with the file delays and then used FL to maintain the delay close to a desired value
- First published a “reduced” algorithm, using only network load as an input,
- Them, took into account also user’s priority, as a function of subscription and handoff

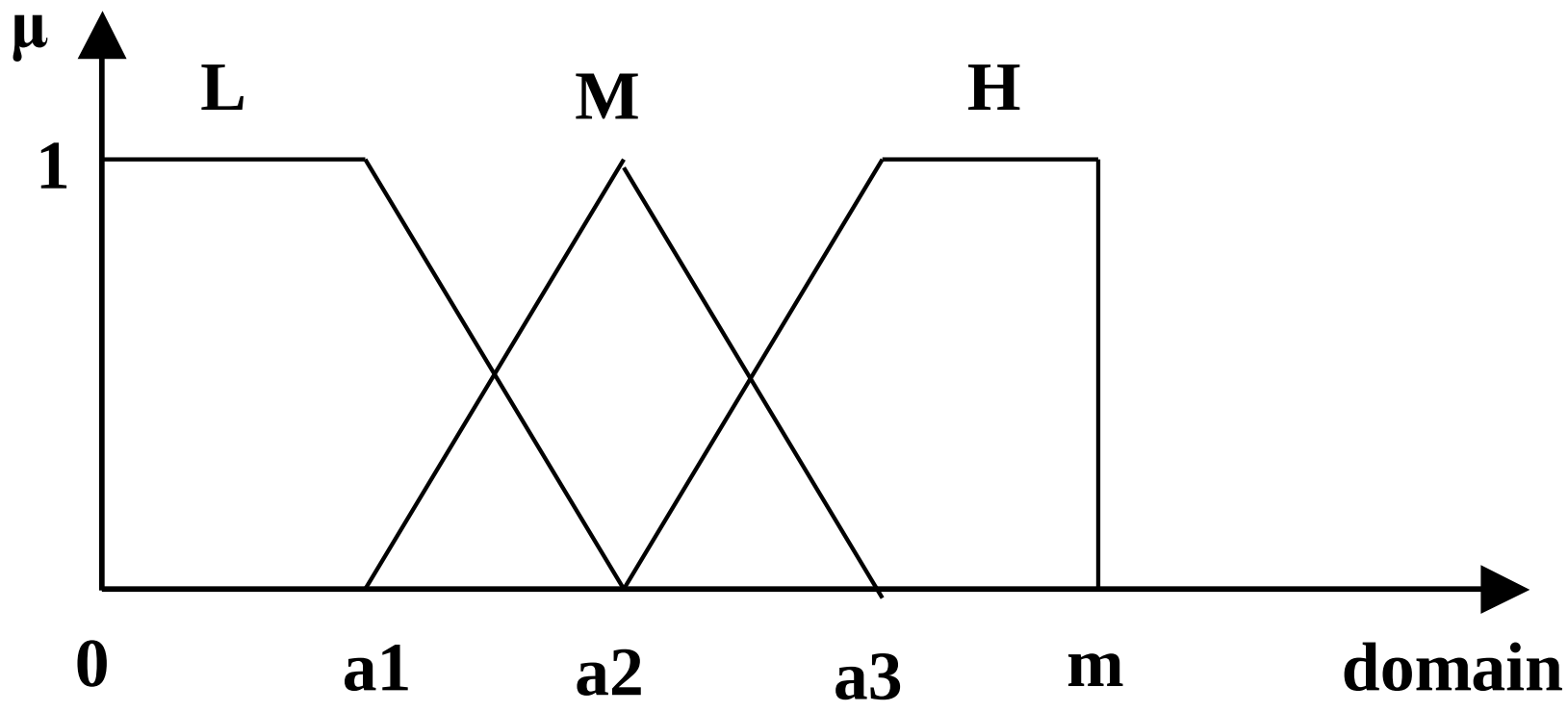
Fuzzy logic based AC

- Advantages of fuzzy logic:
  - No mathematical model needed for traffic characteristics, call durations, etc
  - Reduced computational complexity (compared with MDP)
  - Can use directly the expertise of network operators
- Fuzzy rules: IF *network load* is **high (medium, low)** AND *user's precedence* is **low (normal, high)** THEN *admission decision* is **strong reject SR (weak reject WR, weak admit WA, strong admit SA)**
- Our method: extension of the threshold algorithms through the framework of fuzzy logic

Fuzzy rules

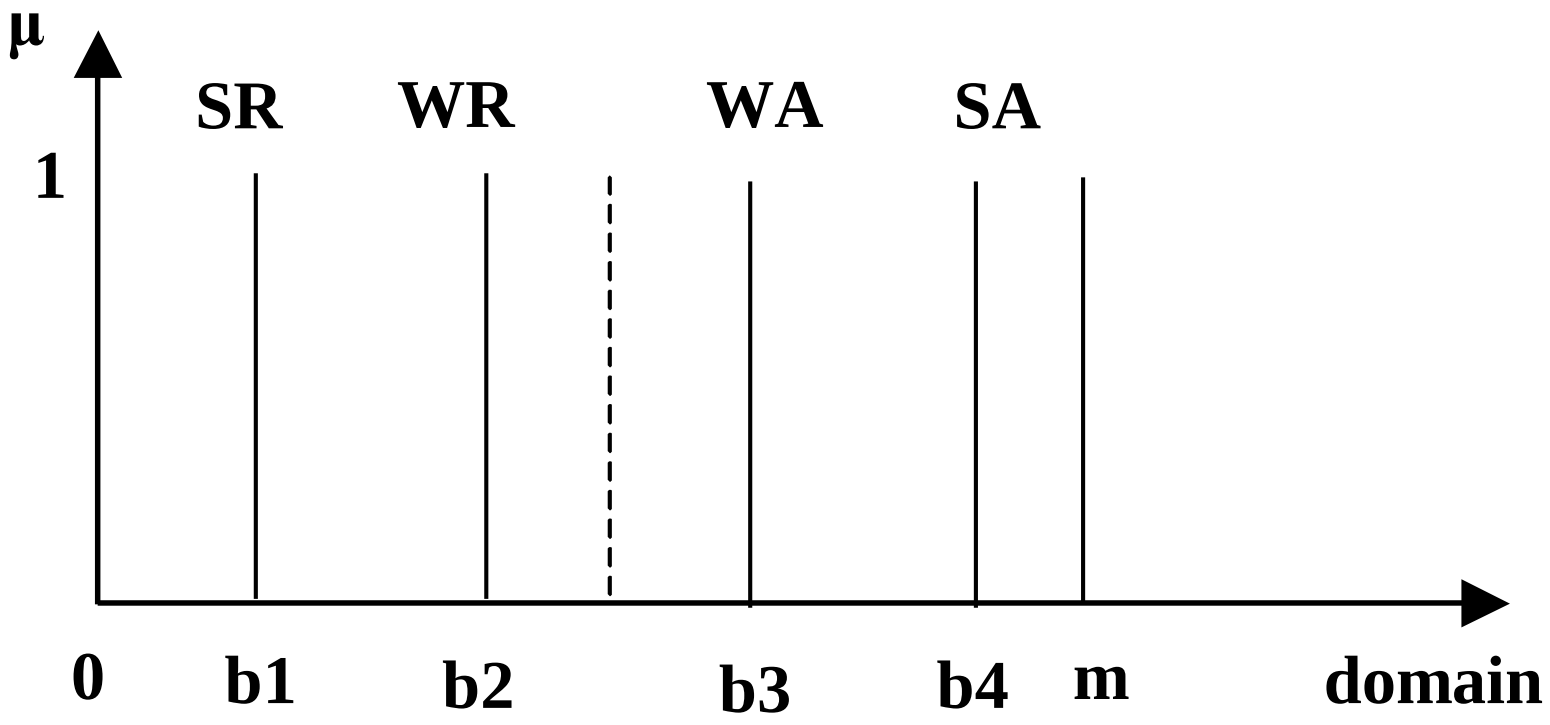
		User's precedence		
		L	**M**	**H**
Net work Load	**L**	WA	SA	SA
	M	WR	WA	SA
	H	SR	WR	WA

Fuzzy terms in premises
(network load, users precedence)



a1= m/4 , a2=m/2 , a3= 3m/4

Fuzzy terms in conclusion
(admission decision)



b1=m/8 ; b2=3m/8 ; b3=5m/8 ; b4=7m/8

Fuzzy inference