Adaptive Multi-fuzzy Engines for Handover Decision in Heterogeneous Wireless Networks

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01.

Introduction

Introduction

Architecture of heterogeneous wireless mobile network (HWMN)

- multiple wireless technologies (Cellular, WLAN)
- aiming to support seamless mobility as well as seamless services

Seamless services - › Services shall support various traffic types, like VoIP or video streaming

Seamless mobility -› HWMN is required to be able to shift mobile devices' connections from a home network to a foreign network in HWMN environment. The two networks may or may not have the same characteristics, but may offer different advantages

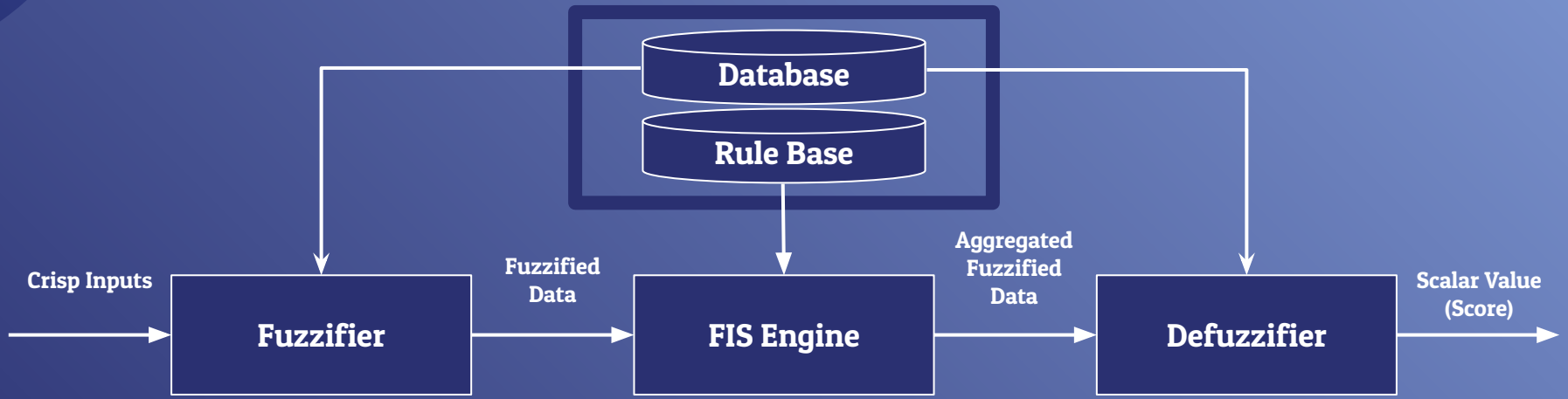
Mobile devices have to move across overlapping service areas -› Handover Process:

- Horizontal handover -› single decision parameter (Received Signal Strength)
- Vertical handover -› a number of parameters, far more complex

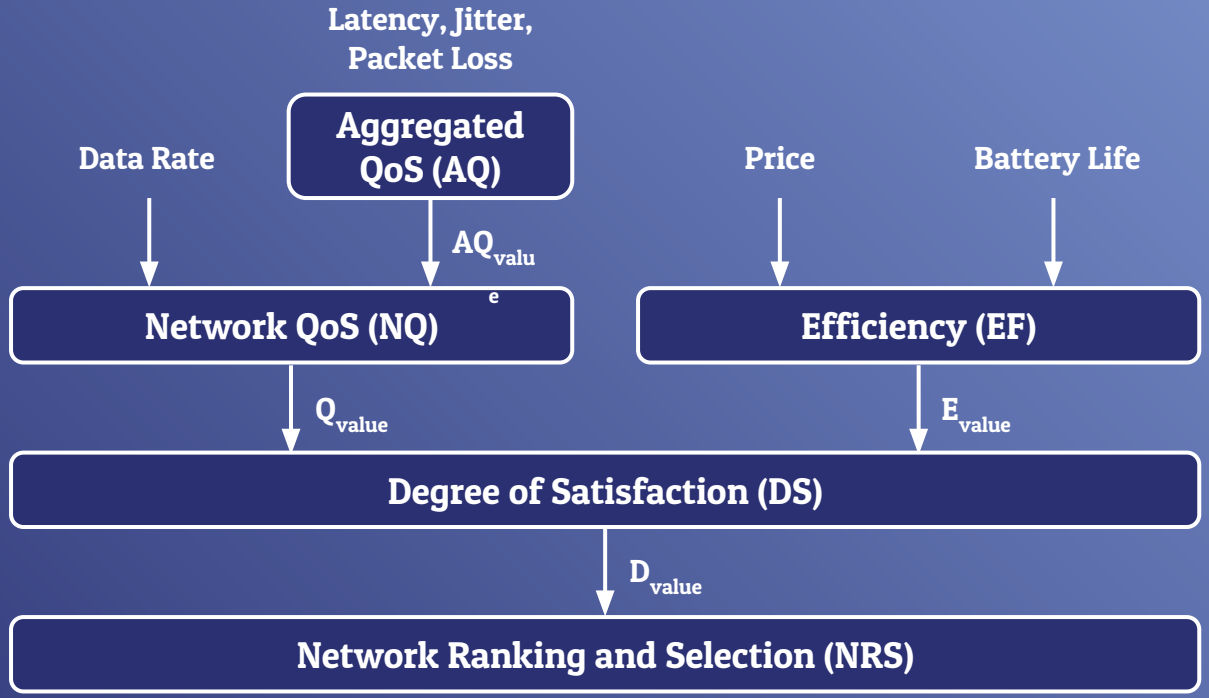
02.

Design & Development

Fuzzy System



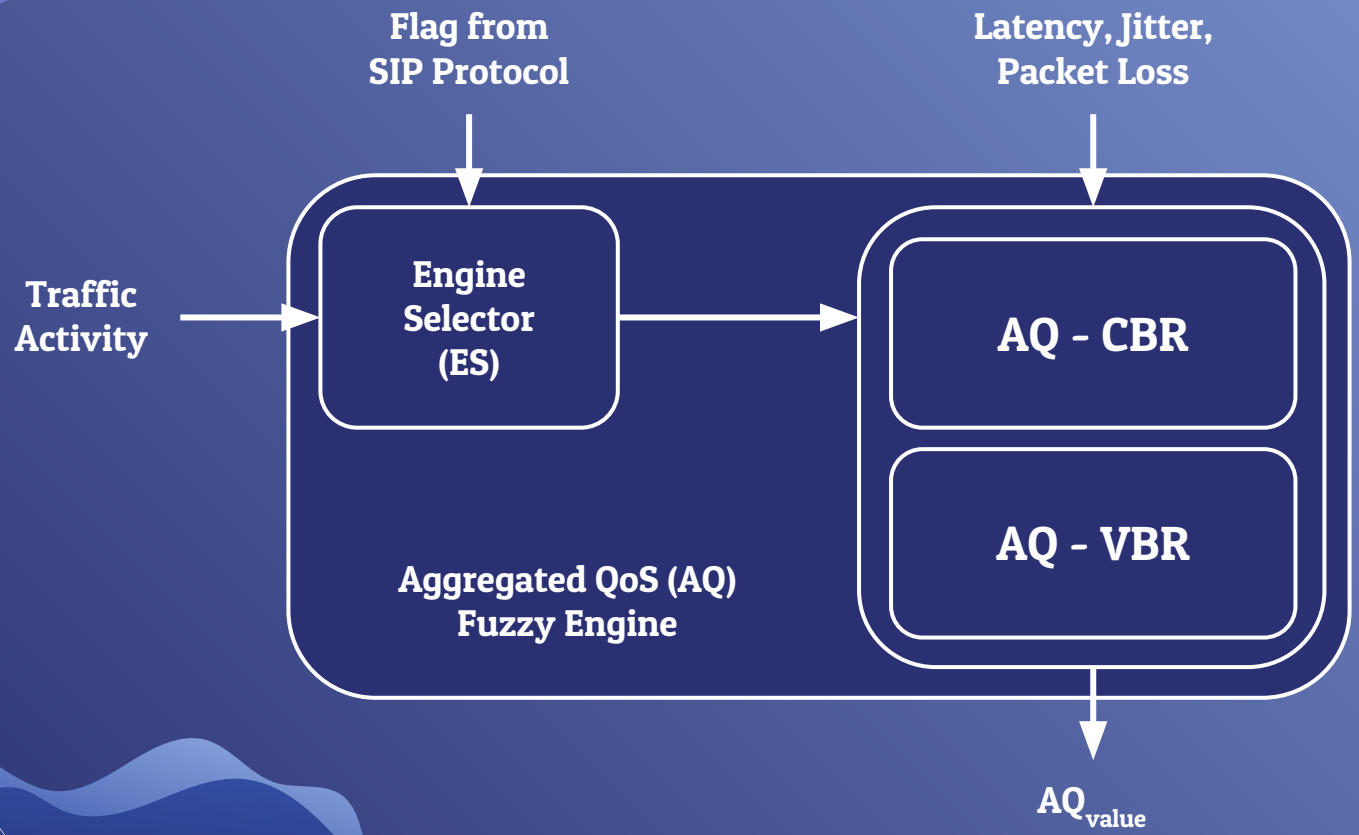
AMHDS II

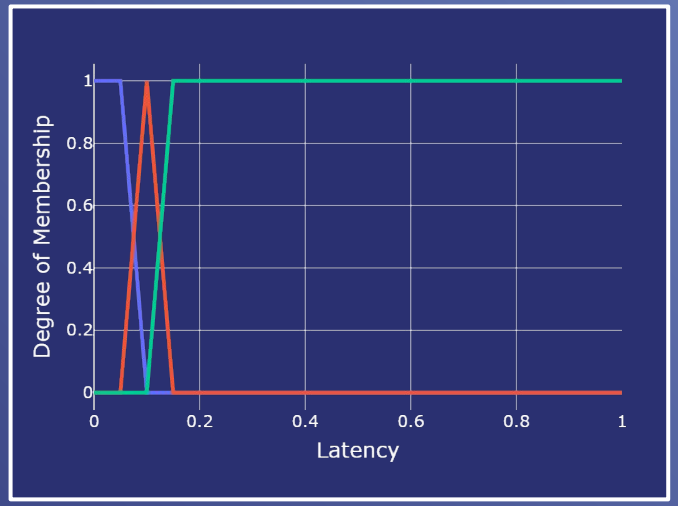

Latency, Jitter, Packet Loss
Aggregated QoS (AQ)
Data Rate
Price
Battery Life
AQvalue
Network QoS (NQ)
Efficiency (EF)
Qvalue
Evalue
Degree of Satisfaction (DS)
Dvalue
Network Ranking and Selection (NRS)

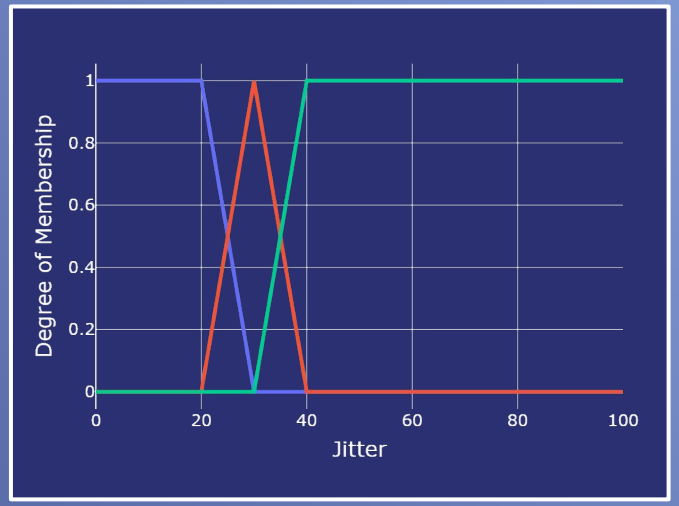
03.

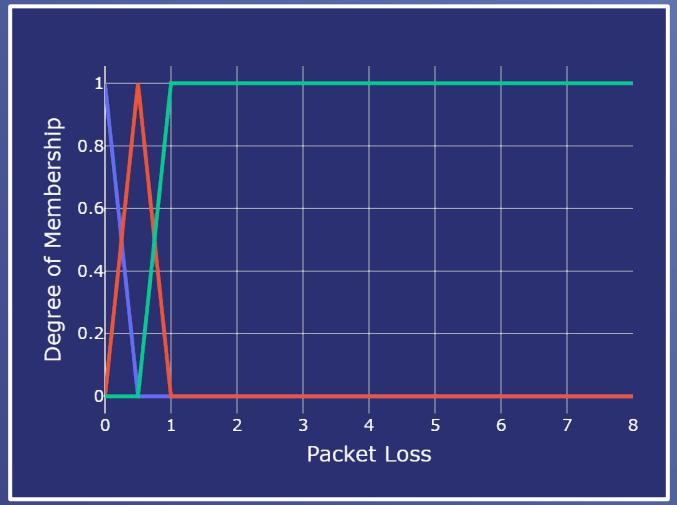
Engines

AQ Engine


Flag from
SIP Protocol
Latency, Jitter,
Packet Loss
Traffic
Activity
Engine
Selector
(ES)
AQ - CBR
AQ - VBR
Aggregated QoS (AQ)
Fuzzy Engine
AQvalue

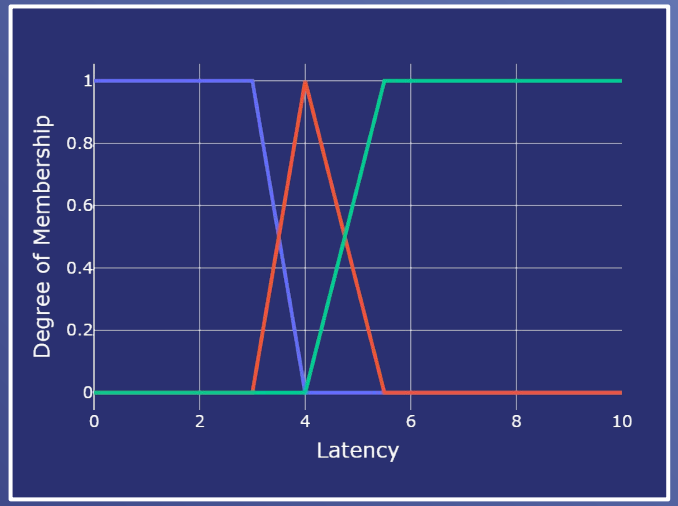


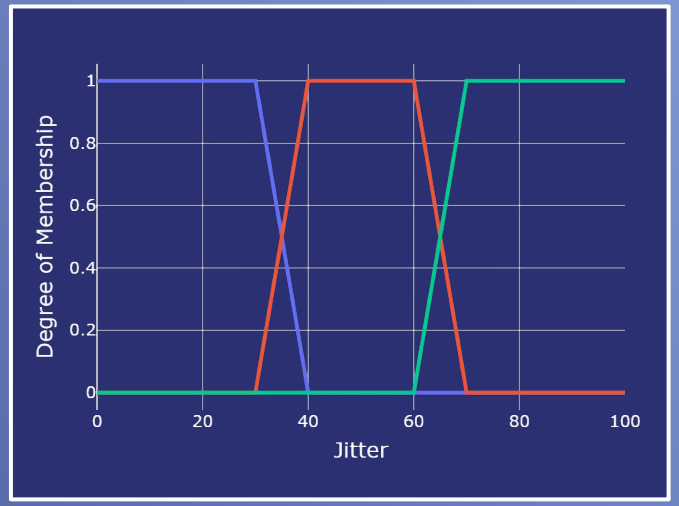


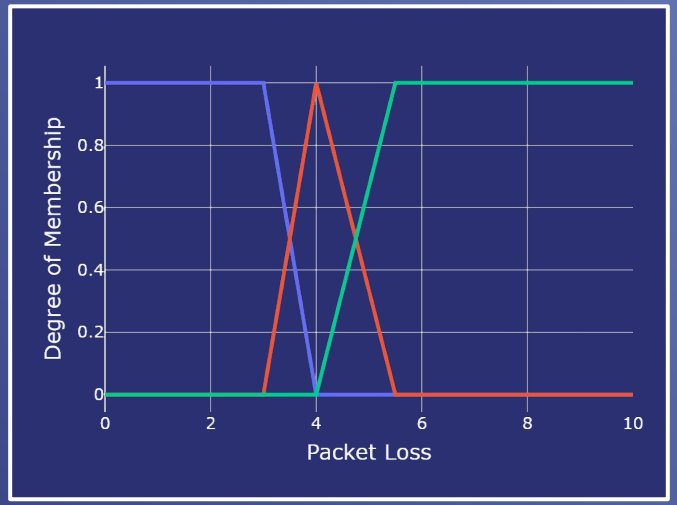


Fuzzy Membership Functions

AQ-CBR







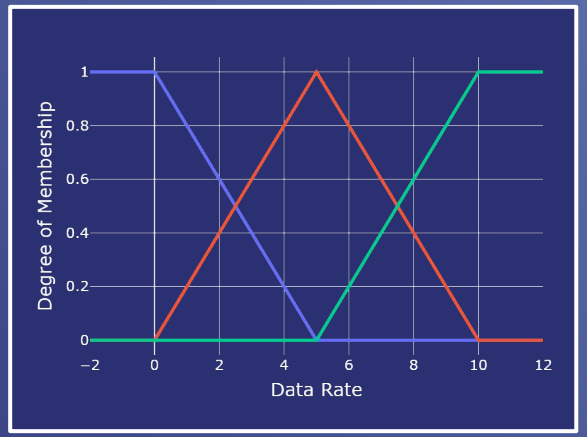
Fuzzy Membership Functions

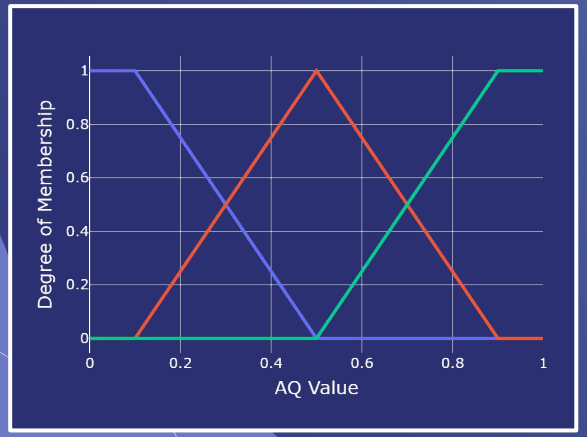
AQ-VBR

Fuzzy Decision Rules
AQ-CBR
AQ-VBR

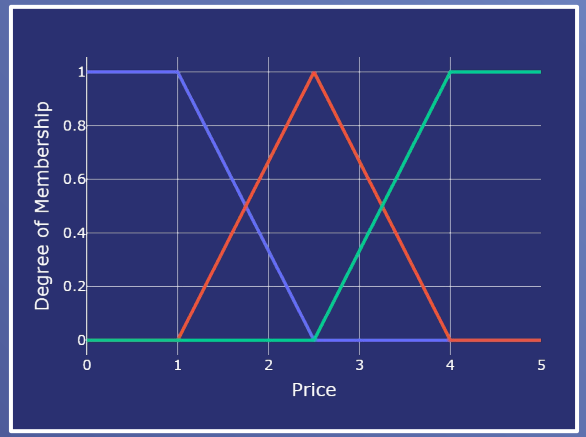
Rule	LA	JI	PL	Output (AQ-CBR)	Output (AQ-VBR)
1	LOW	LOW	LOW	HIGH	HIGH
2	LOW	LOW	MEDIUM	MEDIUM	MEDIUM-HIGH
3	LOW	LOW	HIGH	LOW	LOW
4	LOW	MEDIUM	LOW	MEDIUM	HIGH
5	LOW	MEDIUM	MEDIUM	MEDIUM-LOW	MEDIUM-HIGH
6	LOW	MEDIUM	HIGH	LOW	LOW
7	LOW	HIGH	LOW	MEDIUM-LOW	HIGH
8	LOW	HIGH	MEDIUM	LOW	MEDIUM
9	LOW	HIGH	HIGH	LOW	LOW
10	MEDIUM	LOW	LOW	MEDIUM-HIGH	MEDIUM-HIGH
11	MEDIUM	LOW	MEDIUM	MEDIUM-LOW	MEDIUM
12	MEDIUM	LOW	HIGH	LOW	LOW
13	MEDIUM	MEDIUM	LOW	MEDIUM-LOW	MEDIUM-HIGH
14	MEDIUM	MEDIUM	MEDIUM	LOW	MEDIUM
15	MEDIUM	MEDIUM	HIGH	LOW	LOW
16	MEDIUM	HIGH	LOW	LOW	MEDIUM
17	MEDIUM	HIGH	MEDIUM	LOW	LOW
18	MEDIUM	HIGH	HIGH	LOW	LOW
19	HIGH	LOW	LOW	LOW	LOW
20	HIGH	LOW	MEDIUM	LOW	LOW
21	HIGH	LOW	HIGH	LOW	LOW
22	HIGH	MEDIUM	LOW	LOW	LOW
23	HIGH	MEDIUM	MEDIUM	LOW	LOW
24	HIGH	MEDIUM	HIGH	LOW	LOW
25	HIGH	HIGH	LOW	LOW	LOW
26	HIGH	HIGH	MEDIUM	LOW	LOW
27	HIGH	HIGH	HIGH	LOW	LOW

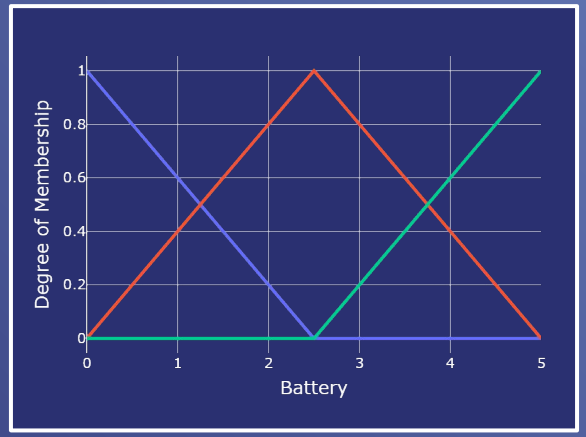
NQ Engine



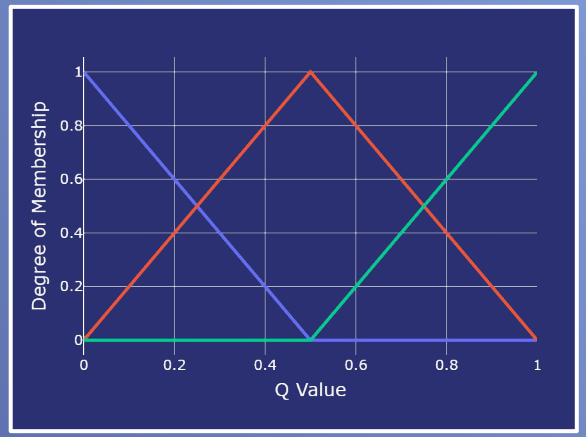


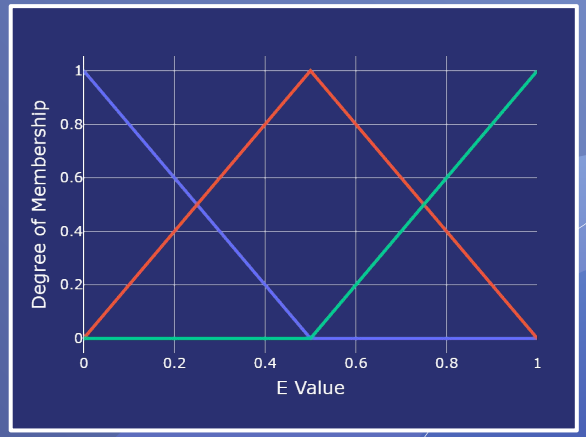
EF Engine





DS Engine





NQ Engine

Rule	DR	AQ_{value}	Output
1	LOW	LOW	LOW
2	LOW	MEDIUM	MEDIUM-LOW
3	LOW	HIGH	MEDIUM
4	MEDIUM	LOW	LOW
5	MEDIUM	MEDIUM	MEDIUM
6	MEDIUM	HIGH	MEDIUM-HIGH
7	HIGH	LOW	LOW
8	HIGH	MEDIUM	MEDIUM-HIGH
9	HIGH	HIGH	HIGH

EF Engine

Rule	PR	BA	Output
1	LOW	LOW	MEDIUM
2	LOW	MEDIUM	MEDIUM-HIGH
3	LOW	HIGH	HIGH
4	MEDIUM	LOW	MEDIUM-LOW
5	MEDIUM	MEDIUM	MEDIUM
6	MEDIUM	HIGH	MEDIUM-HIGH
7	HIGH	LOW	LOW
8	HIGH	MEDIUM	MEDIUM-LOW
9	HIGH	HIGH	MEDIUM

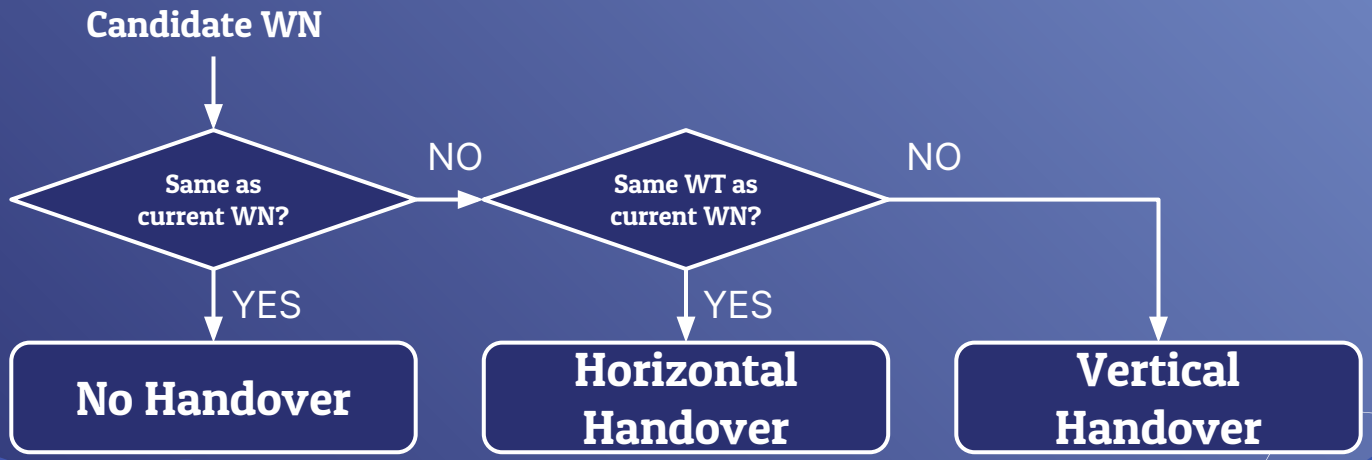
Fuzzy Decision Rules

Rule	Q_{value}	E_{value}	Output
1	LOW	LOW	LOW
2	LOW	MEDIUM	MEDIUM-LOW
3	LOW	HIGH	MEDIUM
4	MEDIUM	LOW	MEDIUM-LOW
5	MEDIUM	MEDIUM	MEDIUM
6	MEDIUM	HIGH	MEDIUM-HIGH
7	HIGH	LOW	MEDIUM
8	HIGH	MEDIUM	MEDIUM-HIGH
9	HIGH	HIGH	HIGH

DS Engine

NRS Engine

After D_{value} for individual candidate wireless networks is determined, NRS engine will rank wireless networks based on their D_{value}. A wireless network having the highest D_{value} is chosen for a handover and NRS engine proceeds with a handover execution process:



04.

Simulation & Results

Simulation

Handover Decision Systems:

- AMHDS Design II-rfr
- AMHDS Design II
- AMHDS Design I
- Simple Additive Weighting (SAW)
- Analytic Hierarchy Process (AHP)

} Non-fuzzy algorithms

Wireless Technologies:

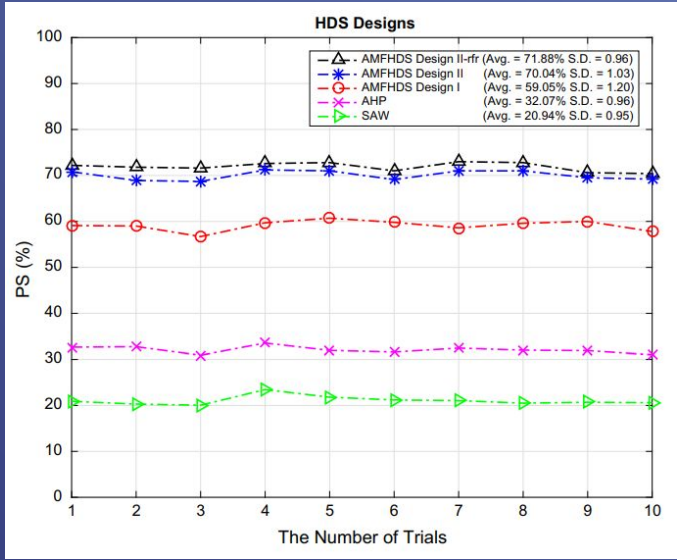
- Cellular (1x)
- WiMAX (2x)
- WLAN (5x)

Traffic Types

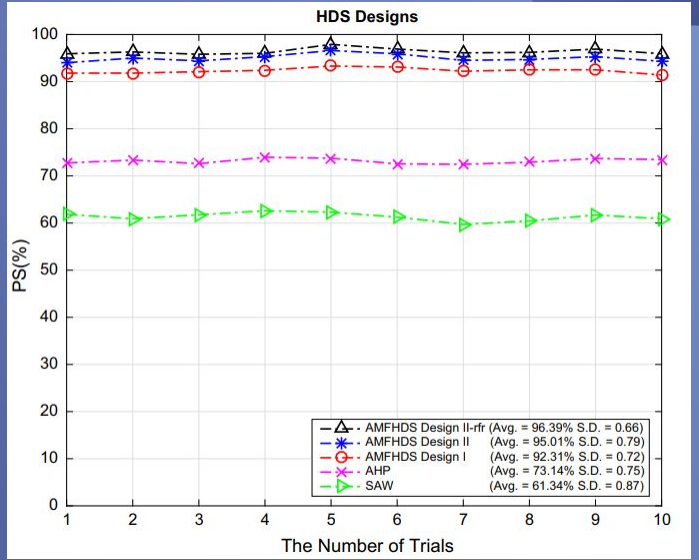
- VoIP (64kbps)
- Video Streaming

(1 and 4 Mbps / 360p and 720p)

Results



VoIP



Video Streaming

05.

Conclusion

Conclusion

- Adaptive and modular design approaches have the potential to enhance the intelligence of HDS for HWMN
- The performance of fuzzy-based techniques is superior to AHP and SAW techniques, even though the τ for AHP and SAW is significantly lower than fuzzy-based techniques
- Even more can be done by including mobility-based parameters (velocity, movement pattern, etc.)
- Additionally, it is observed that a certain number of fuzzy decision rules can be removed as some fuzzy decision rules may contribute to the same decision output

Thank You