QoS Aware Fuzzy Rule Based Vertical Handoff Decision Algorithm for Heterogeneous Wireless Networks

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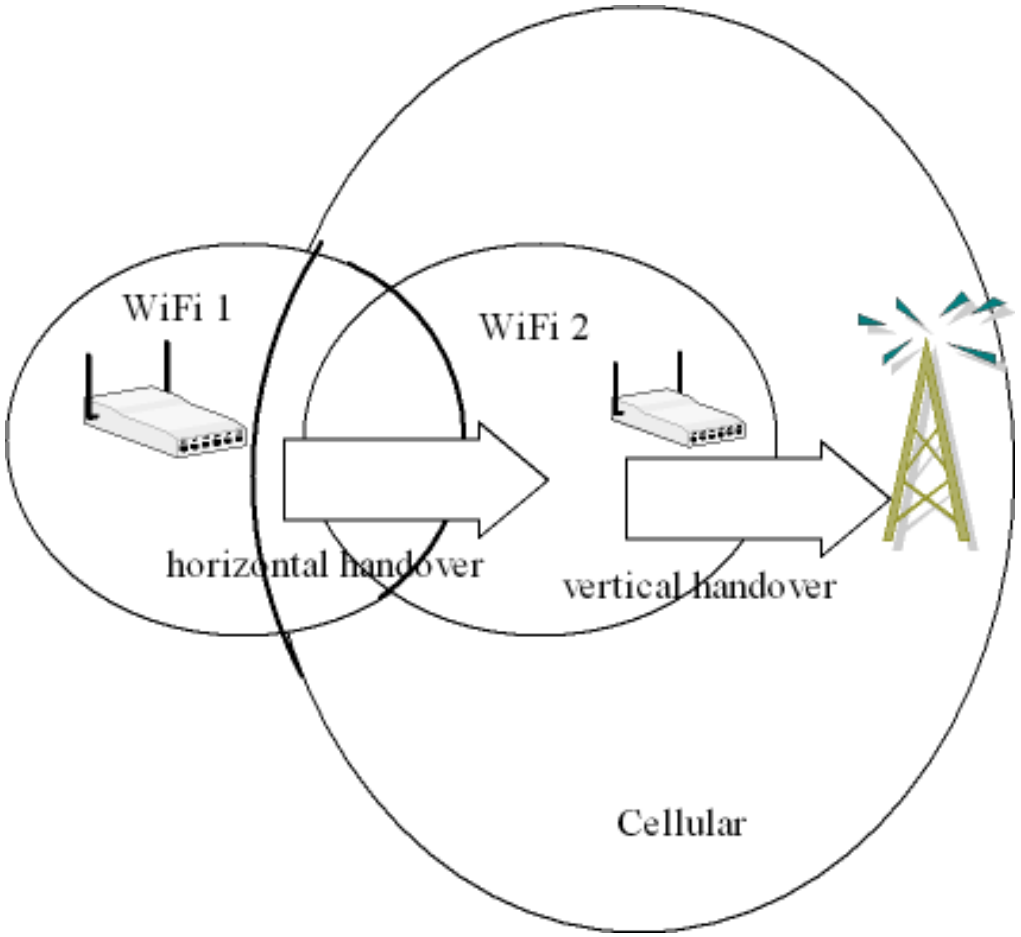
Outline

- Introduction – Vertical handoff
- Highlights of the work
- Fuzzy Rule Based System and Proposed Mechanism
- Evaluation model
- Simulation results
- Implementation in Mobile IP testbed
- Conclusion

Introduction

- Next Generation heterogeneous wireless networks require seamless mobility amongst the different access networks while maintaining QoS for various applications, such as high-speed data services, audio, video, and multimedia applications.
- In such networks it is necessary to employ efficient mobility management strategies to meet QoS requirements for different traffic classes while maintaining a fair utilization of wireless resources.
- Achieved with a good mechanism to handle handoff between two dissimilar networks, known as vertical handoff.

Horizontal and Vertical Handoff



Introduction (Contd.)

- Vertical handoff mechanisms involve three different phases of operations:
  - system discovery
  - handoff decision process
  - handoff execution.
- In system discovery phase, the system may periodically monitor the states of the networks to determine the network to which handoff can be carried out.
- The handoff decision process identifies the network to which handoff can be carried out.

Multi criteria-based decision

- Current literature indicates the advantage of a combination of some of the criteria like bandwidth, RSSI, and delay for making a handoff decision - especially in the presence of heterogeneous networks.
- The wide variation in the characteristics of the networks involved motivates one to explore the field of ***fuzzy logic*** to develop a handoff strategy.

Highlights of the Work

- QoS aware fuzzy rule based vertical handoff decision algorithm.
- Multi-criteria of bandwidth, delay, jitter and bit error rate considered for different traffic classes.
- A New evaluation model using a non birth-death Markov chain for creating the simulation environment.
- Implementation of proposed scheme using Mobile IP testbed at IISc.

IMT2000 QoS Classes and Requirements (3GPP- TS 23.107)

Traffic Class	BER	E2E Delay	Jitter	Bandwidth
Conversational	Need not be Low	Should be Low	Should be Low	Need not be High
Streaming	Need not be Low	Should be Low or Medium	Should be Low	Should be high
Interactive	Should be Low	Should be Medium or Low	Need not be low	Need not be high
Background	Should be Low	Need not be low	Need not be low	Should be Medium atleast

Fuzzy Rule Based System (FRBS)

- Propositional logic - events are symbolized with either 'True/False' values.
- In predicate logic, events are symbolized with values other than just true or false;
- The predicate IsTall

  is probably false for someone who is 4' tall,
  is probably true for someone who is 7' tall,
  is somewhere in between for someone at 5 ½'.

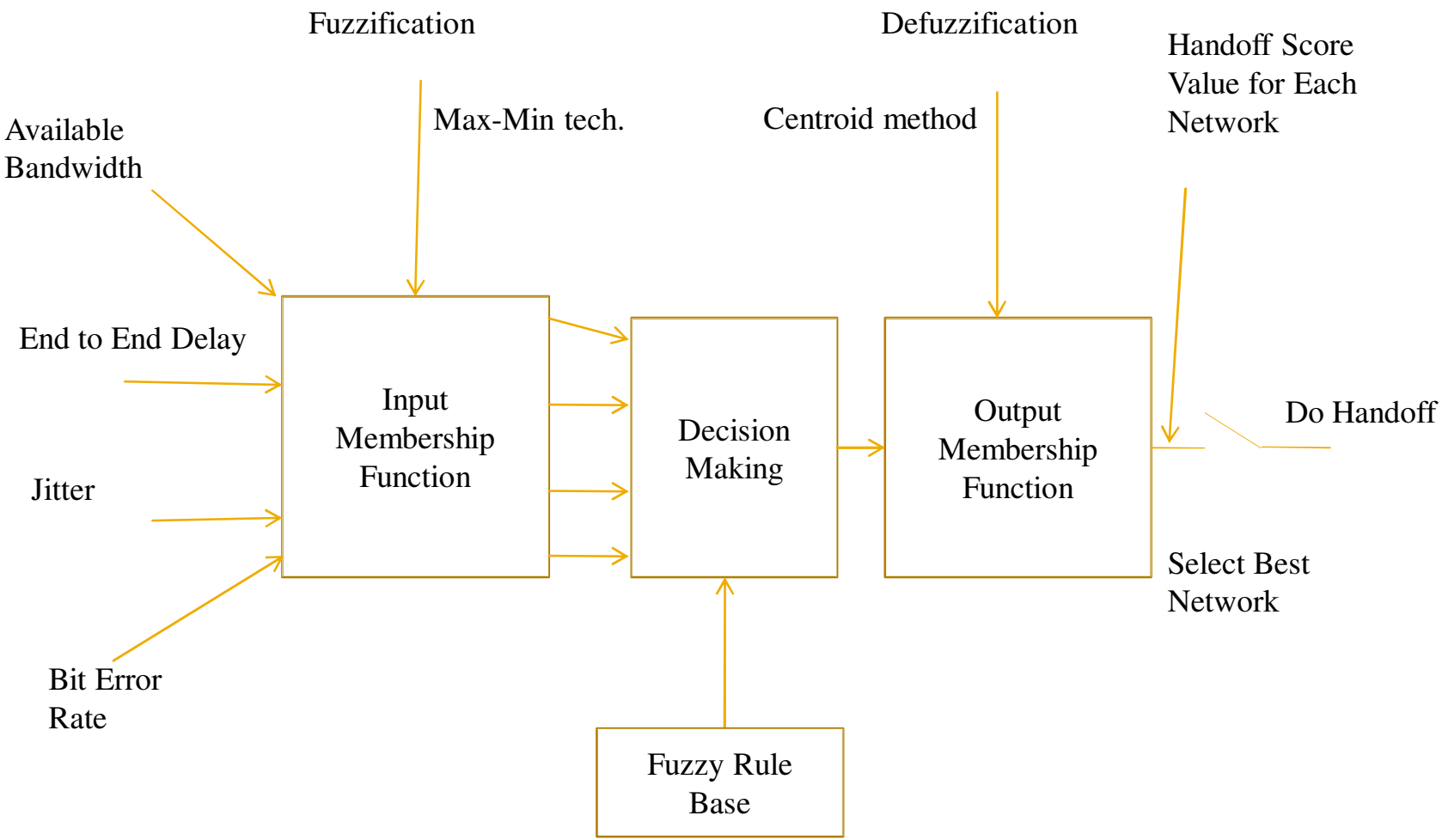
FRBS (Contd.)

- Associated with this linguistic variable is a set membership function that can take on values in the interval [0-1], rather than just from the set {0, 1}.
- A fuzzy set is a set with such a set membership function.

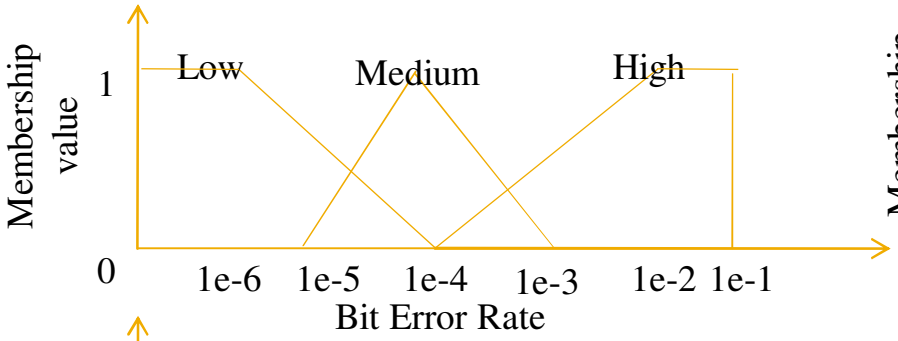
Fuzzyfication and defuzzyfication

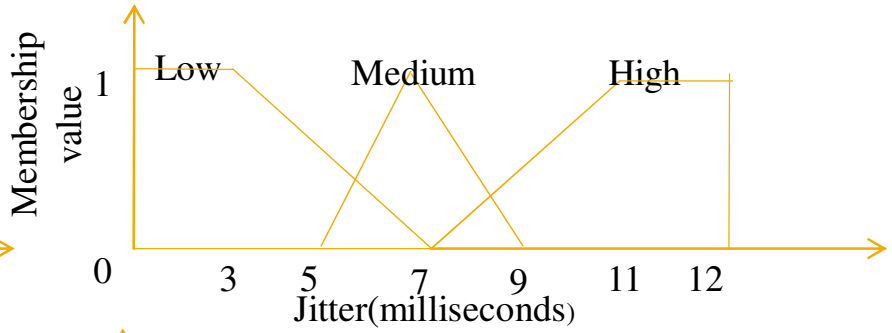
- The process of taking a set of observations and creating a fuzzy set from it is called fuzzification.
- The inverse process is known as defuzzification.

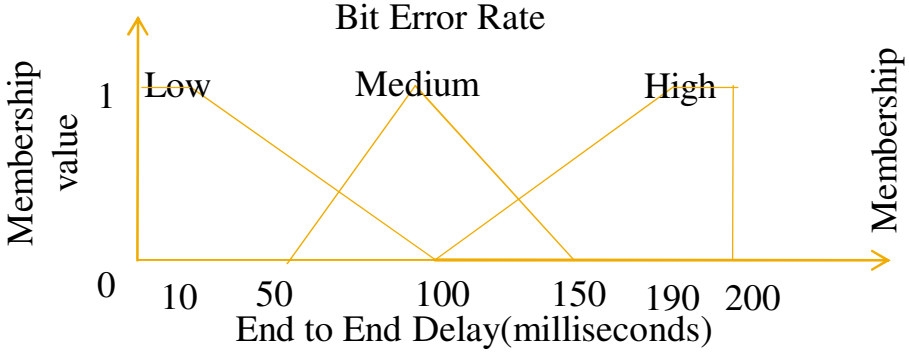
The Proposed Mechanism

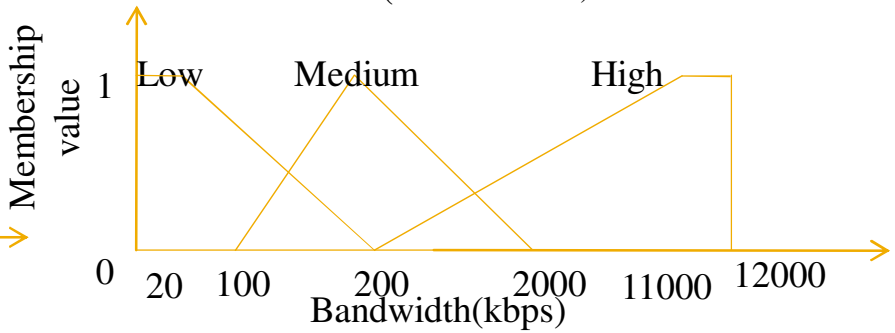


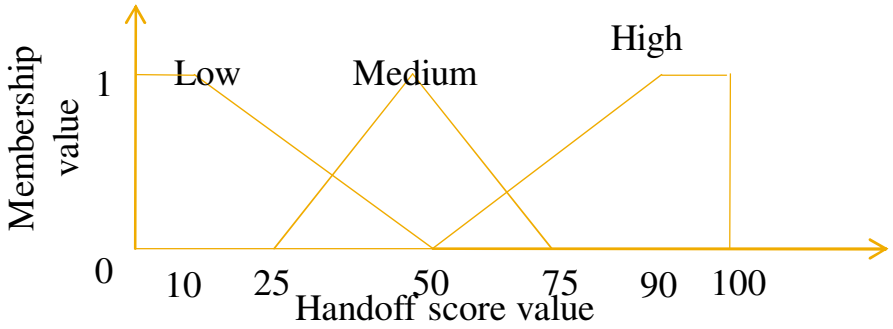
Fuzzy membership functions











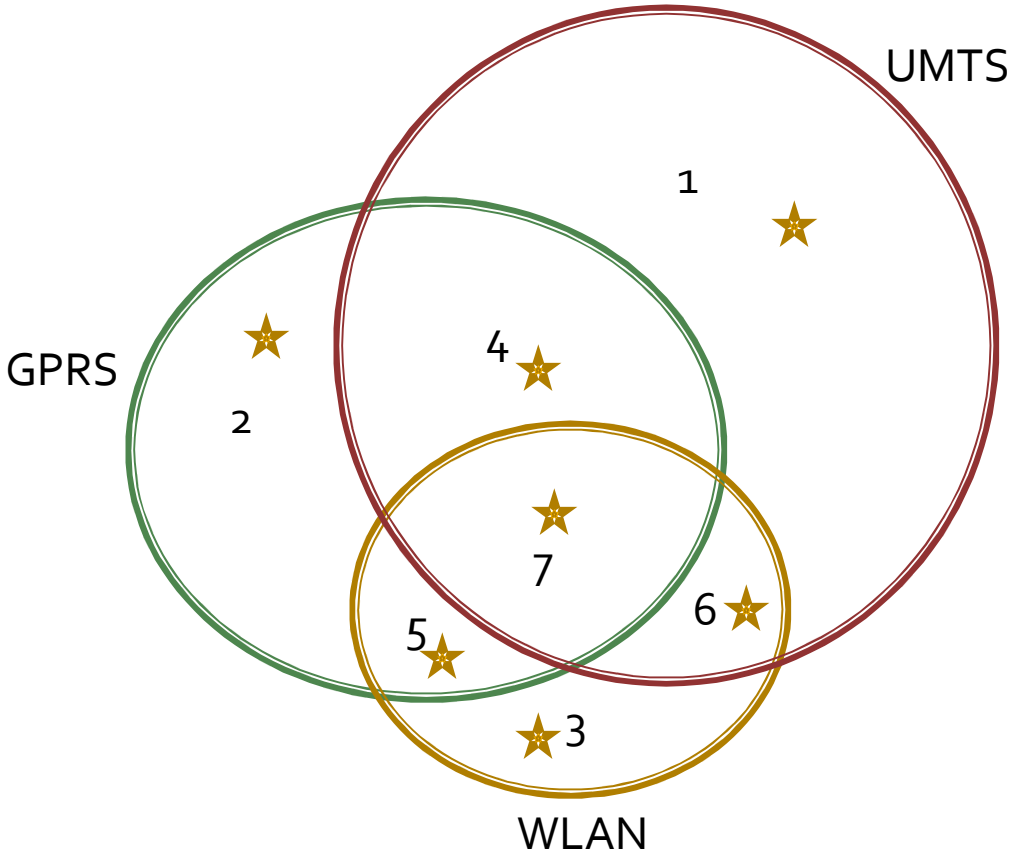
Sample rule base

Conversational					
Rule No	**BER**	**E2E delay**	**Jitter**	**Bandwidth**	**Handoff score**
1	**low**	**low**	**low**	**low**	**high**
25	**low**	**high**	**high**	**low**	**low**
50	**medium**	**high**	**medium**	**medium**	**low**
81	**high**	**high**	**high**	**high**	**low**
Streaming					
Rule No	**BER**	**E2E delay**	**Jitter**	**Bandwidth**	**Handoff score**
1	**low**	**low**	**low**	**low**	**low**
25	**low**	**high**	**high**	**low**	**low**
50	**medium**	**high**	**medium**	**medium**	**high**
81	**high**	**high**	**high**	**high**	**medium**

Sample rule base (Contd.)

Interactive					
Rule No	**BER**	**E2E delay**	**Jitter**	**Bandwidth**	**Handoff score**
1	**low**	**low**	**low**	**low**	**medium**
25	**low**	**high**	**high**	**low**	**low**
50	**medium**	**high**	**medium**	**medium**	**low**
81	**high**	**high**	**high**	**high**	**low**
Background					
Rule No	**BER**	**E2E delay**	**Jitter**	**Bandwidth**	**Handoff score**
1	**low**	**low**	**low**	**low**	**medium**
25	**low**	**high**	**high**	**low**	**medium**
50	**medium**	**high**	**medium**	**medium**	**medium**
81	**high**	**high**	**high**	**high**	**medium**

Wireless Heterogeneous Environment



☆ Mobile node position

0-7 State number

0 -------- No Network

1 -------- { UMTS }

2 -------- { GPRS }

3 -------- { WLAN }

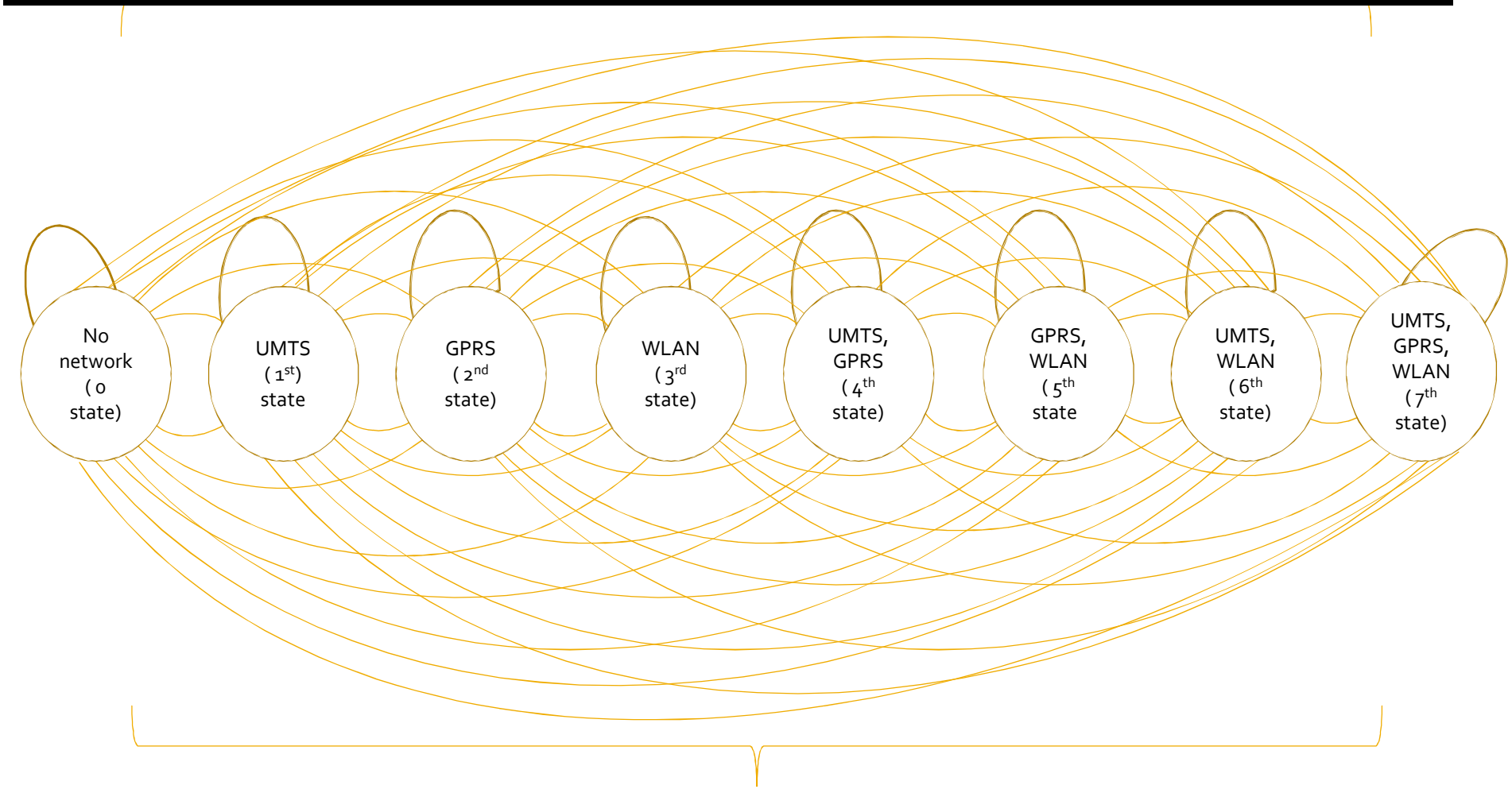
4 -------- { UMTS, GPRS }

5 -------- { GPRS, WLAN }

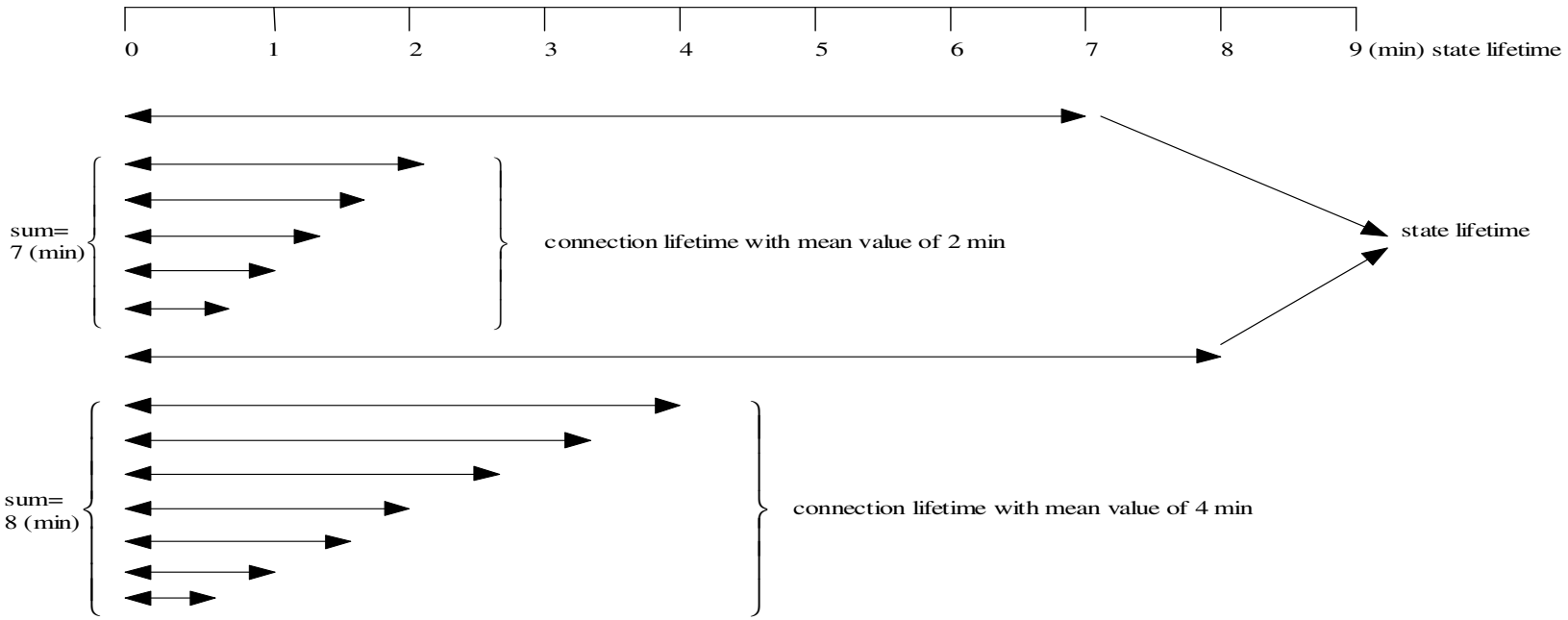
6 -------- { UMTS, WLAN }

7 -------- { UMTS, GPRS, WLAN }

The Non Birth-death Markov Chain



State Lifetime and Connection Lifetime



Simulation Study: Assumptions

1. State transition time (or state lifetime) at state i is assumed to follow an exponential distribution with a mean λ_i.
2. State transitions are instantaneous and do not incur any waiting delays.
3. Within a state, connection lifetimes follow an exponential distribution with a mean μ.

Parameter vectors

- *Bandwidth* vector:
  UMTS - [32, 64, 128, 256, 512, 1024, 2048] kbps
  GPRS - [21, 42, 64, 85, 107, 128, 149, 171] kbps
  WLAN- [1000, 2000, 5500, 11000] kbps
- E-E Delay:
  UMTS– [190, 160, 130, 100, 70, 40, 10]msec
  GPRS– [160, 110, 60, 10]msec
  WLAN– [160, 110, 60, 10]mses
- *Jitter*:
  [3, 5, 7, 9, 11] msec
- Bit-error rate:
  [0.01, 0.001, 0.0001, 0.00001, 0.000001]

Ref. - Stevens-Navarro E. and Wong V. W. S., "Comparison between Vertical Handoff Decision Algorithms for Heterogeneous Wireless Networks", IEEE VTC, vol 2, pages: 947-951, 2006.

Evaluation Metrics

1. End-to-end delay
2. Available bandwidth
3. Jitter
4. Availability - 1-Pr[the mobile is in state 0].

Comparative study

1. SAW (Simple additive weight).

2. TOPSIS (Techniques for order preference by similarity to ideal solution).

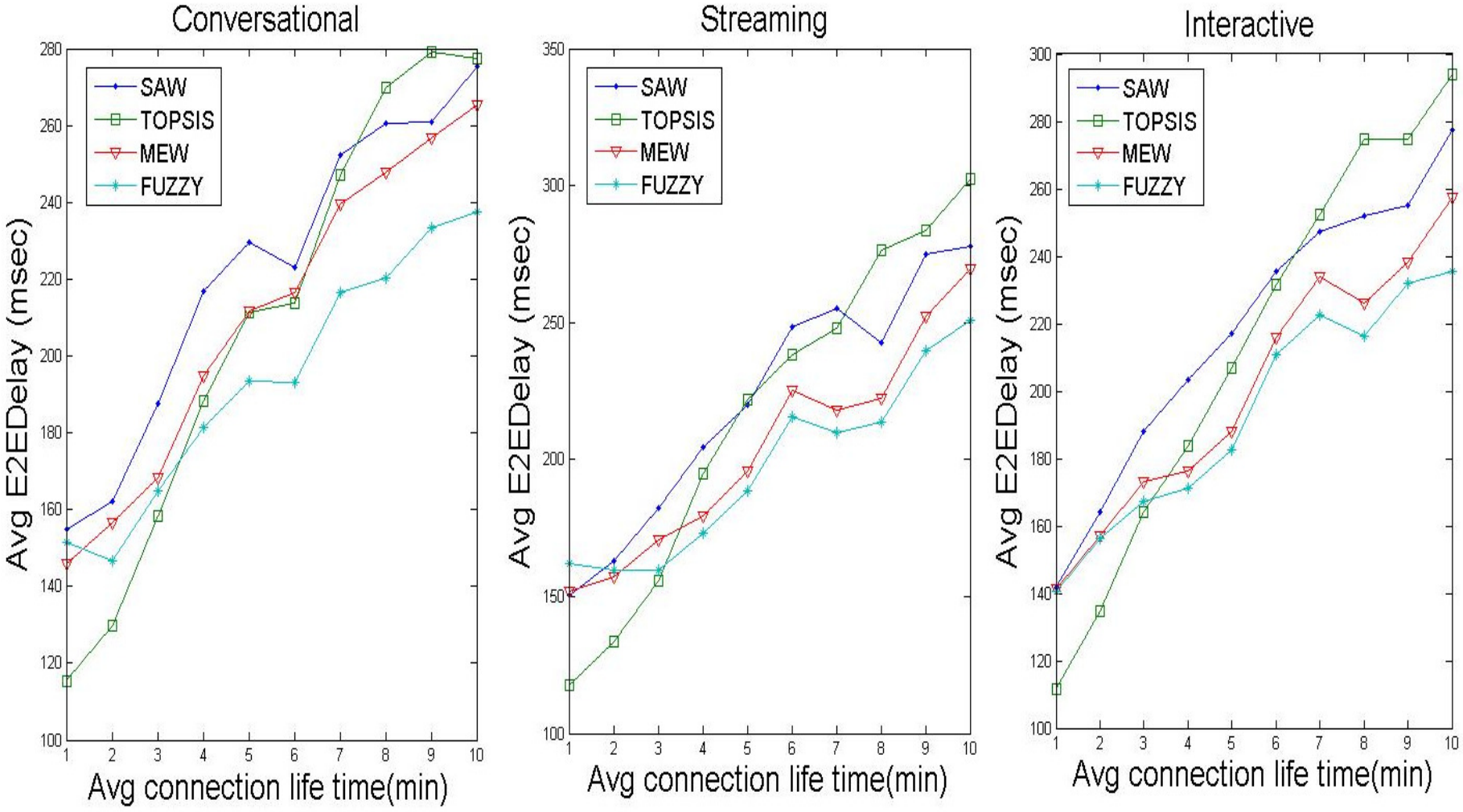
3. MEW (Multiplicative exponent weighting).

Importance weights - AHP

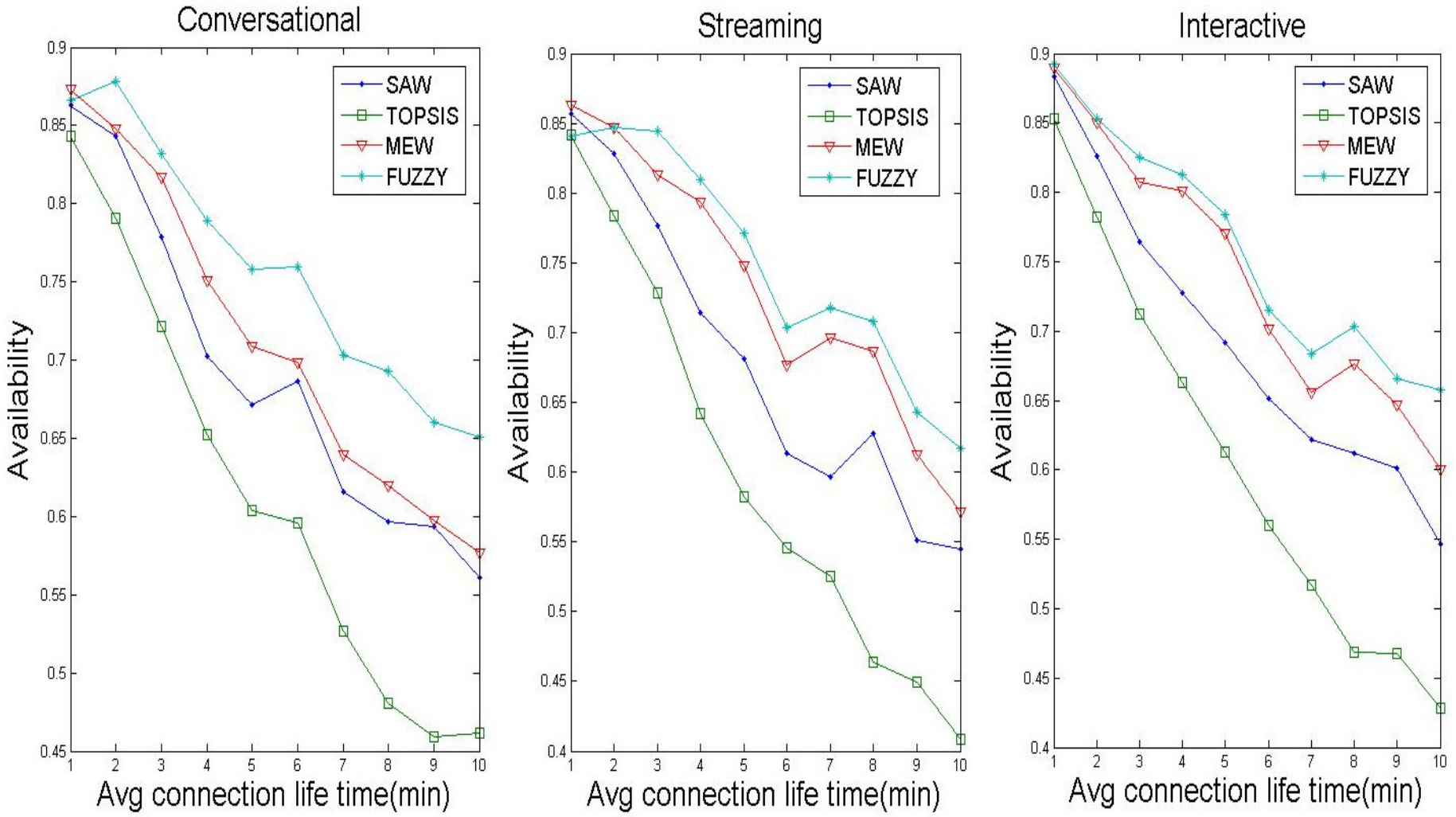
Traffic Class	BER	E2EDelay	Jitter	Bandwidth
Conversational	0.04998	0.45002	0.45002	0.04998
Streaming	0.03737	0.11380	0.42441	0.42441
Interactive	0.63593	0.16051	0.04304	0.16051
Background	0.66932	0.05546	0.05546	0.21976

Ref. - Stevens-Navarro E. and Wong V. W. S., "Comparison between Vertical Handoff Decision Algorithms for Heterogeneous Wireless Networks", IEEE VTC, vol. 2, pages: 947-951, 2006.

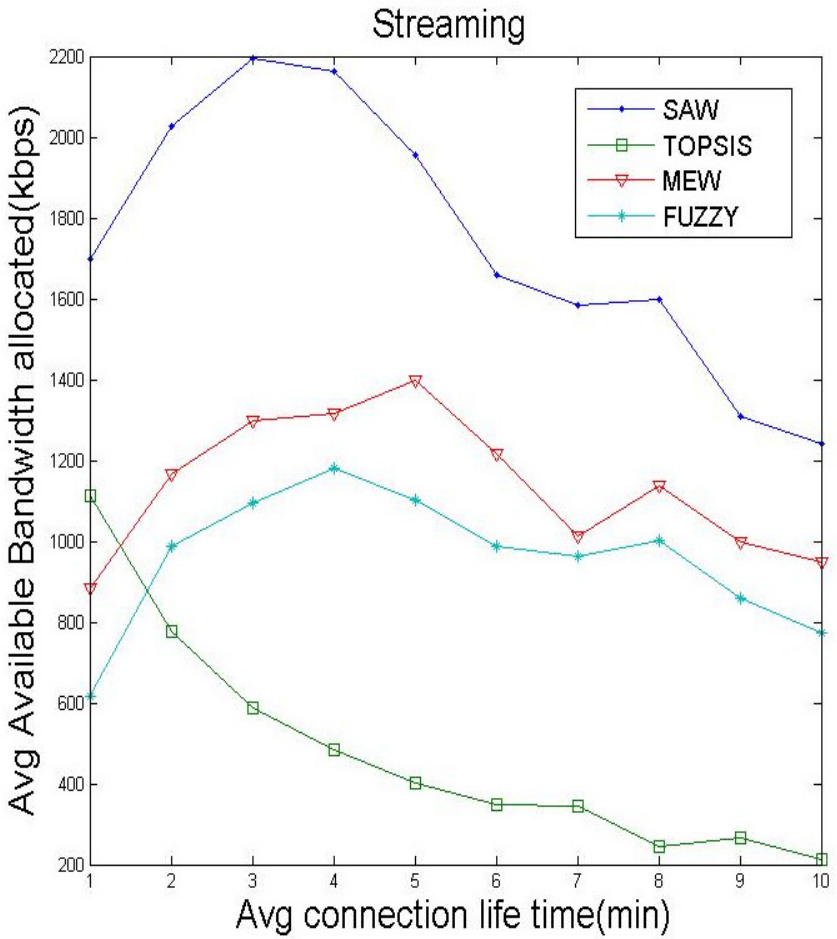
Results -Avg E2E Delay

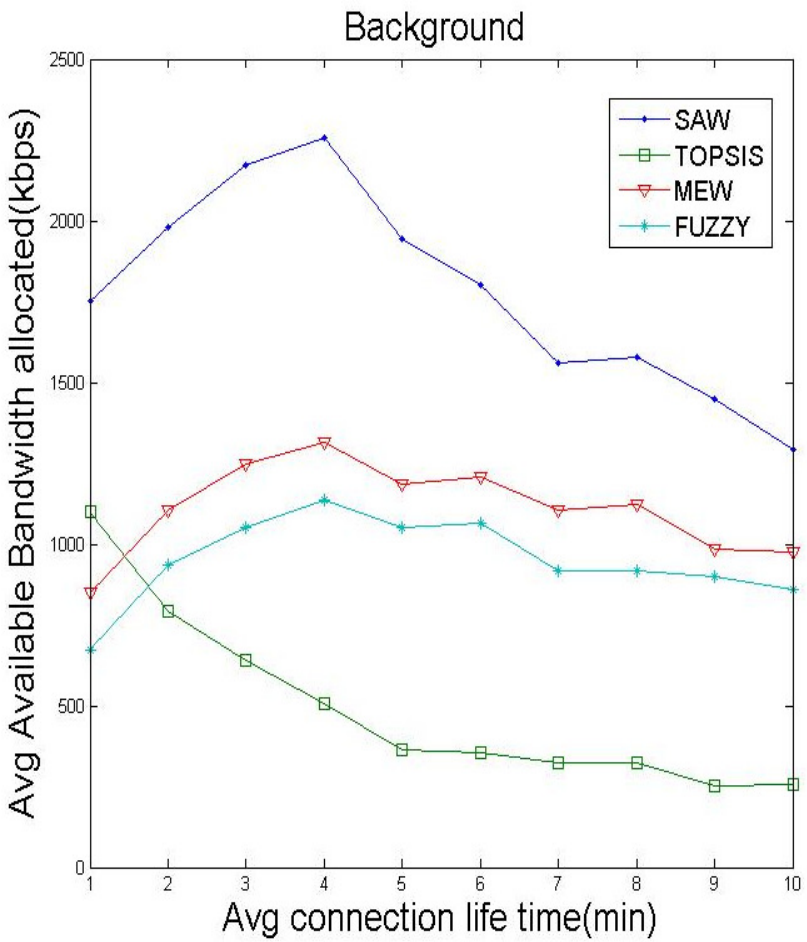


Results -Availability

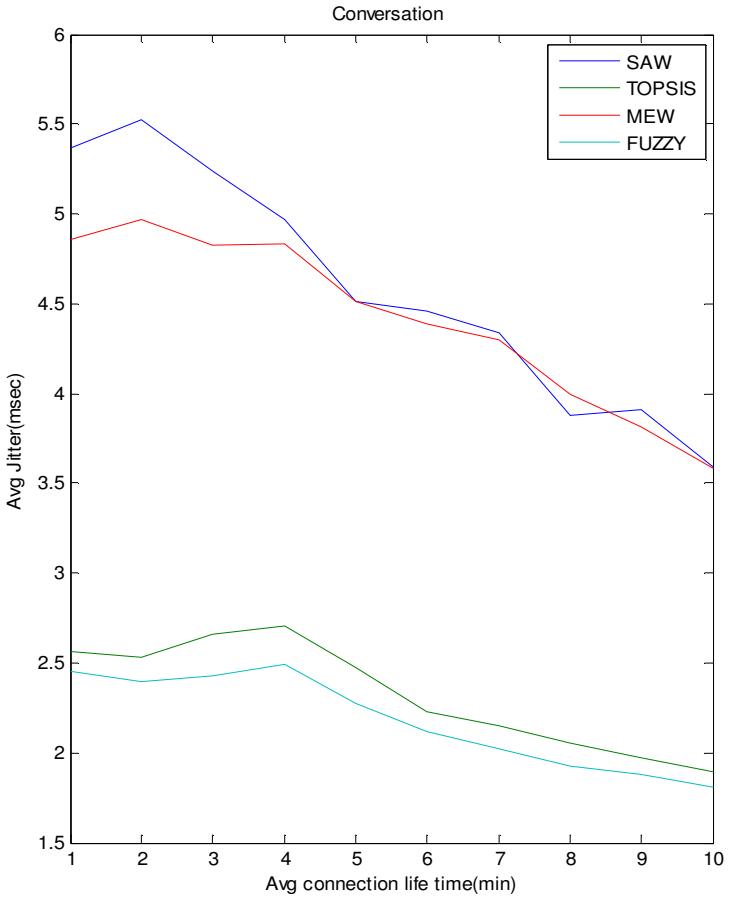


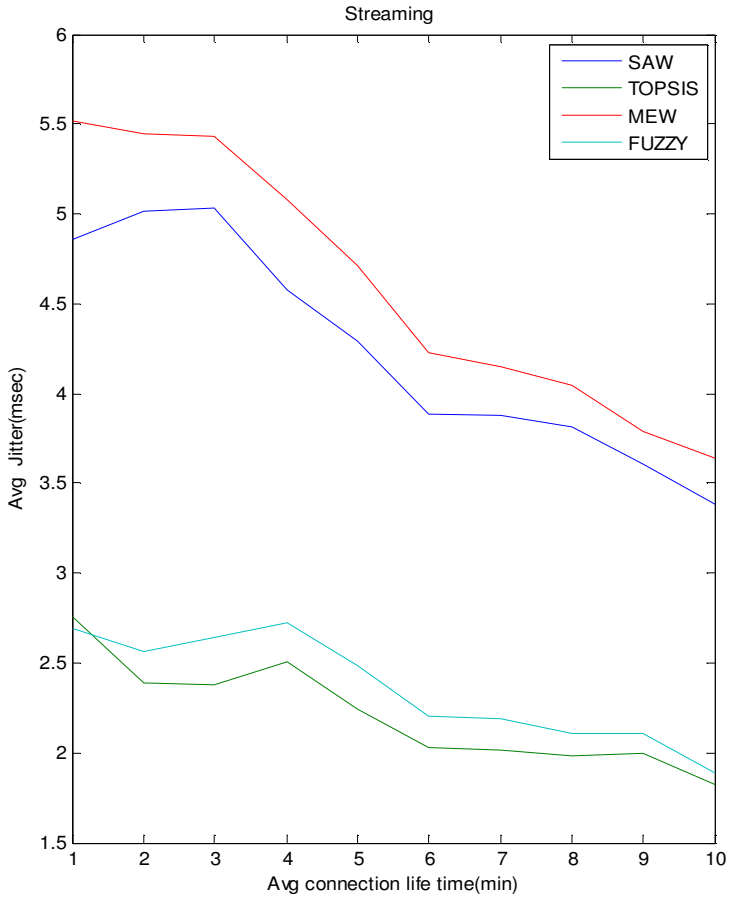
Results -Avg Available BW





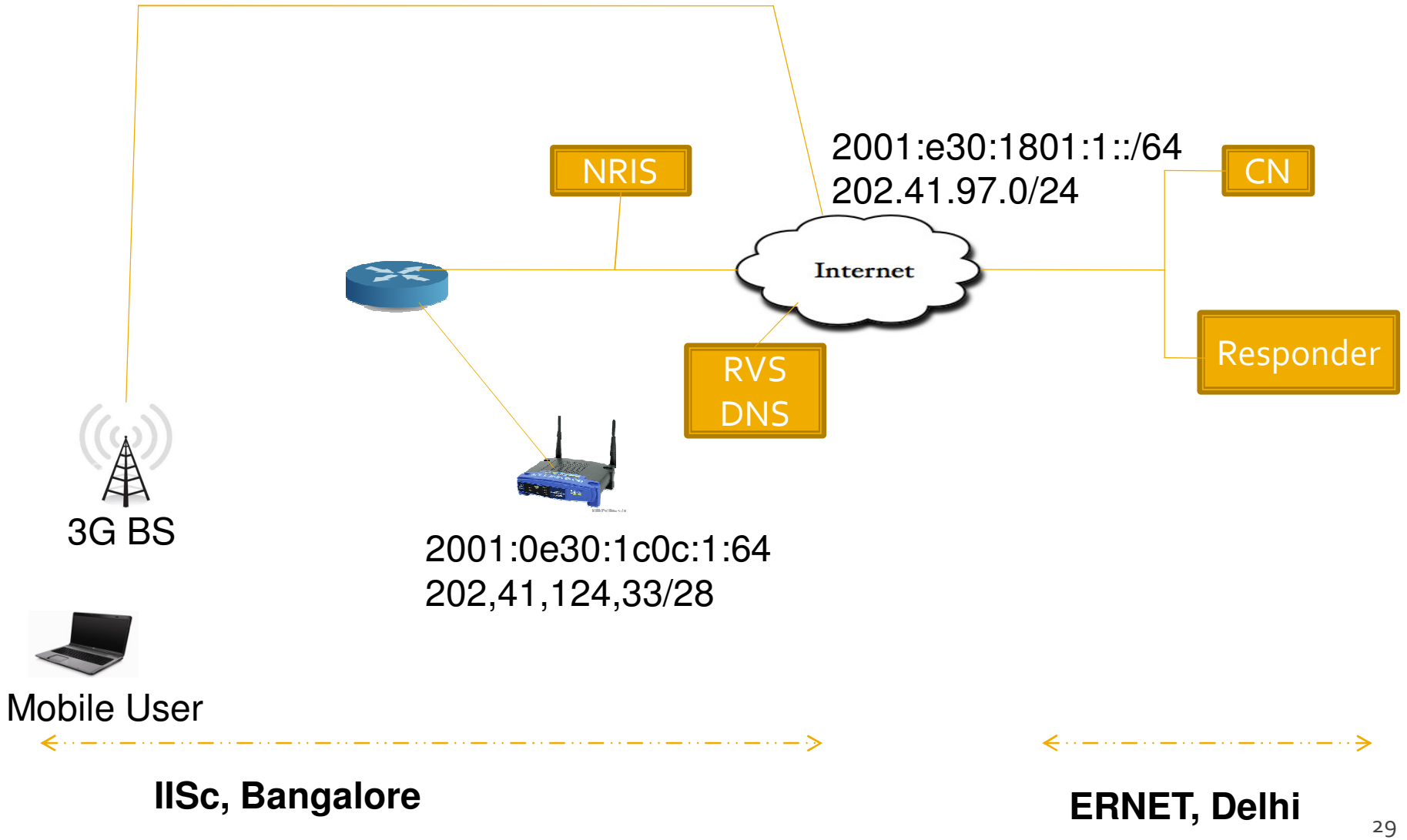
Results -Jitter



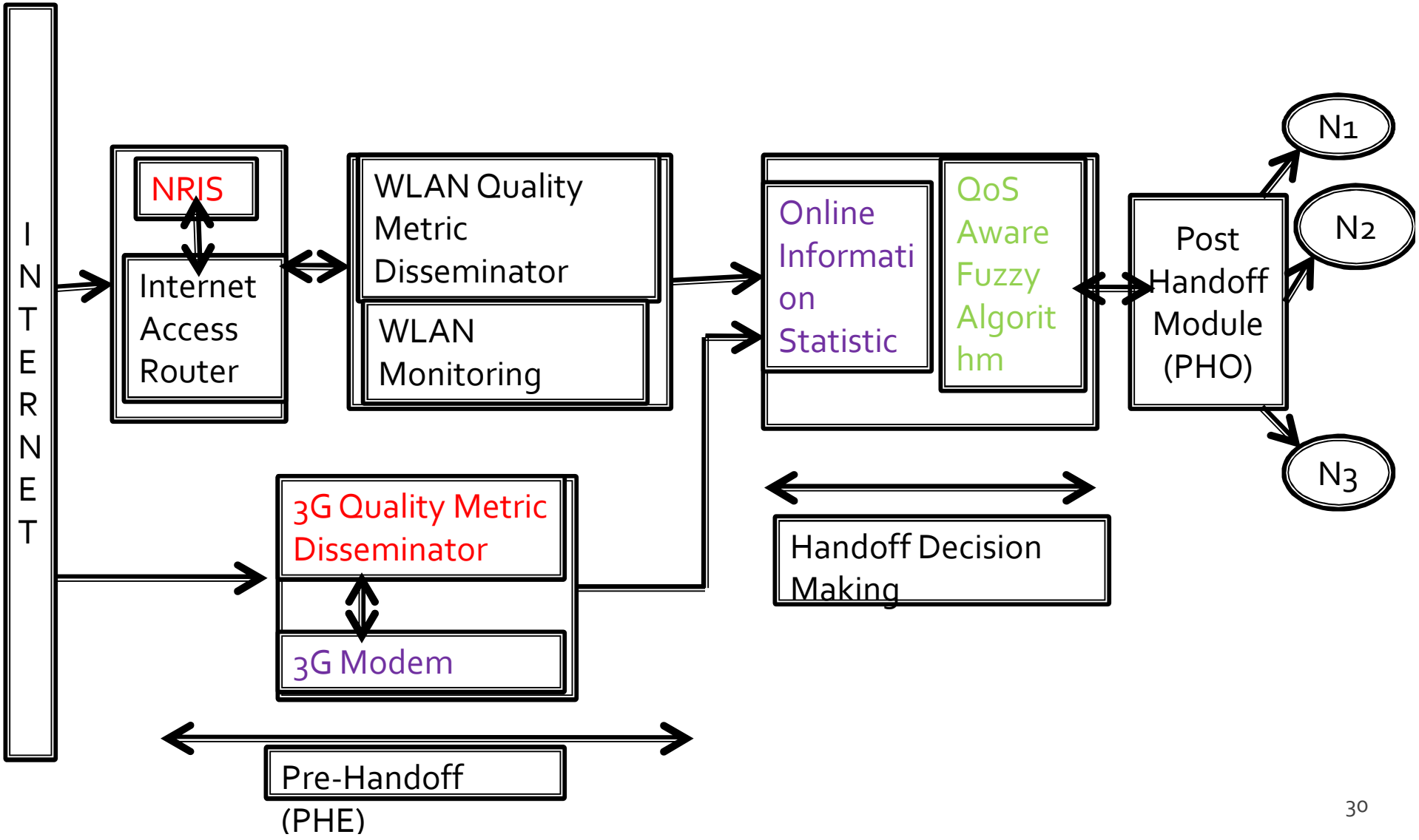


Implementation of QoS Aware FRB Vertical Handover using Mobile IPv6 testbed at IISc,Bangalore

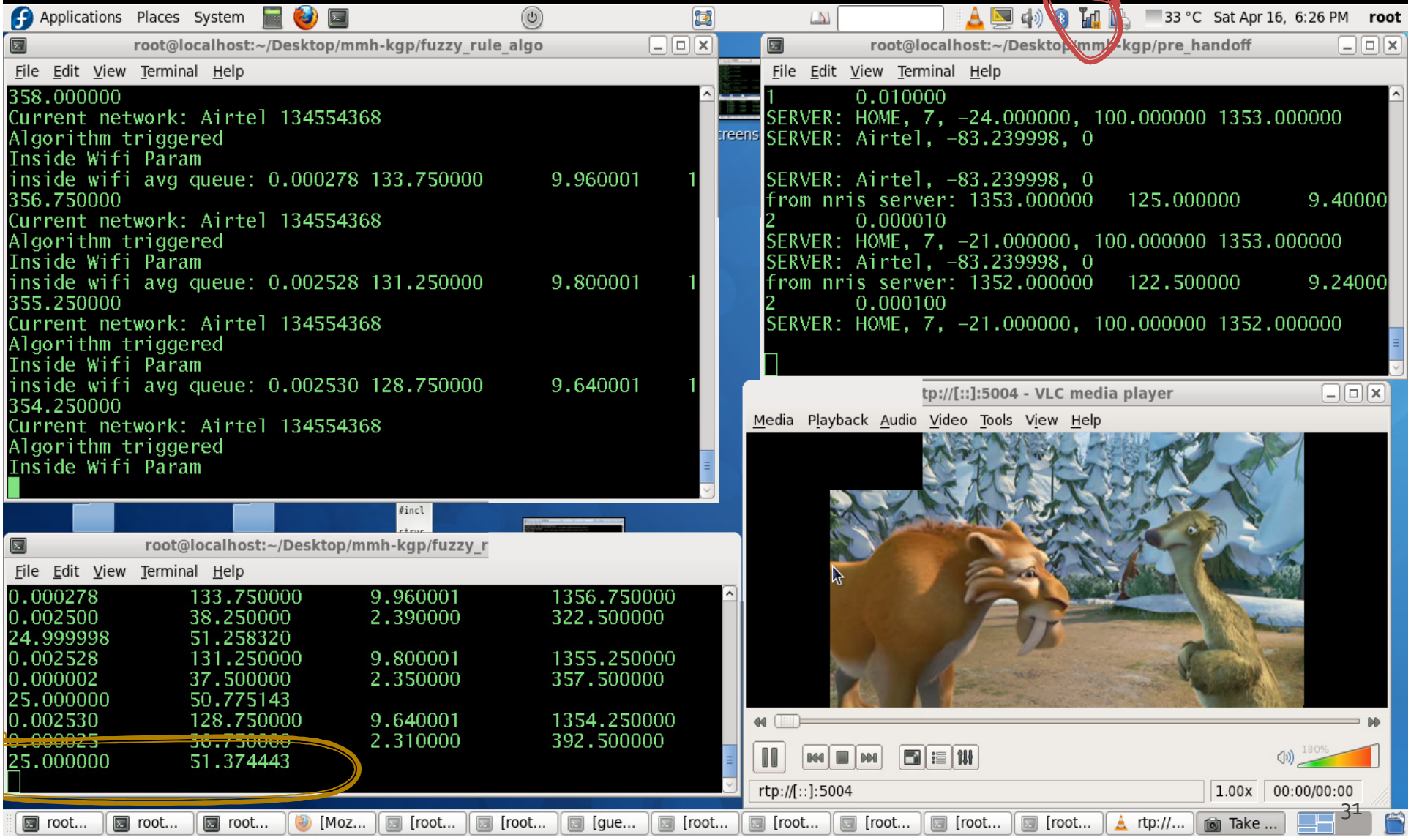
MobileIPv6 testbed



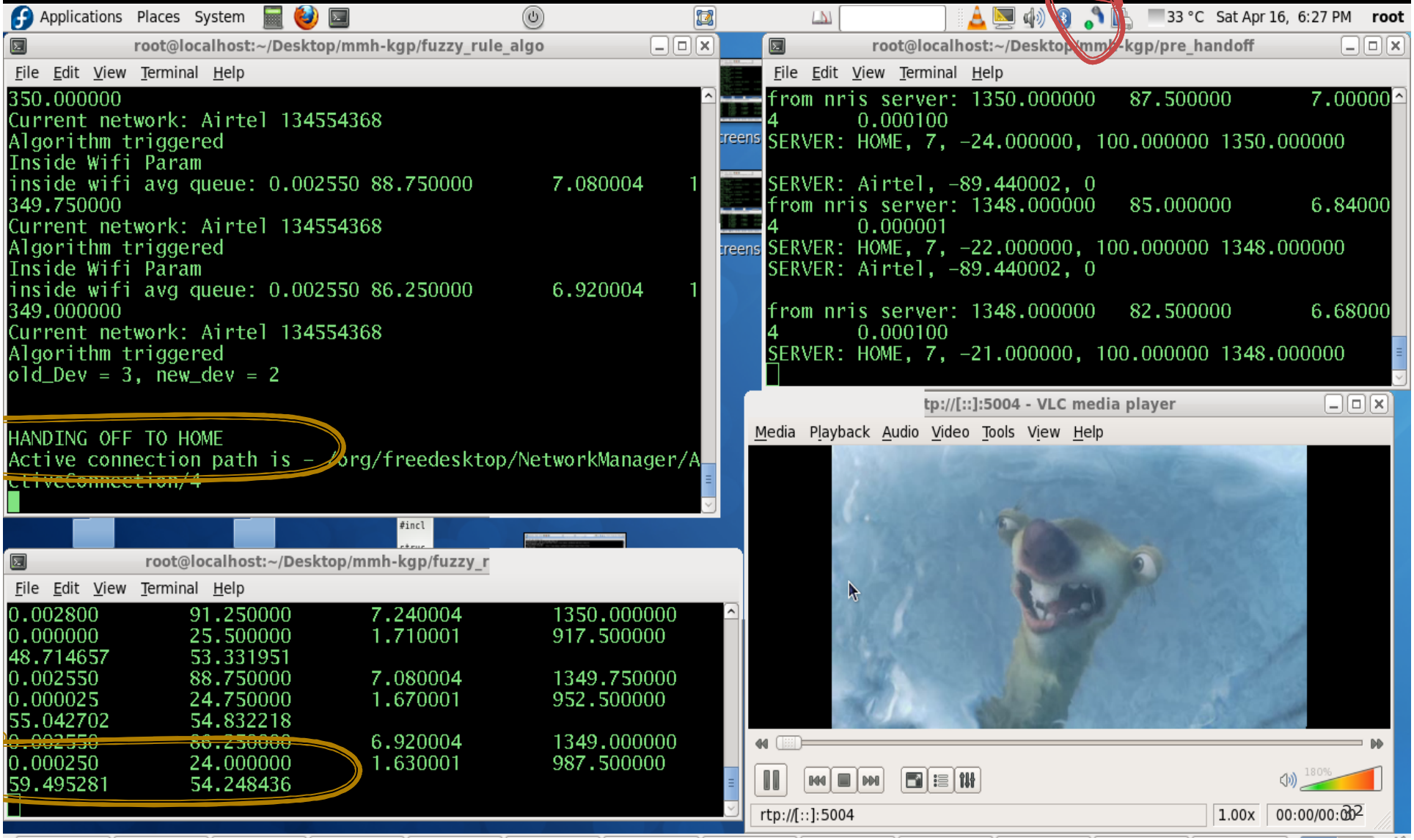
Software architecture



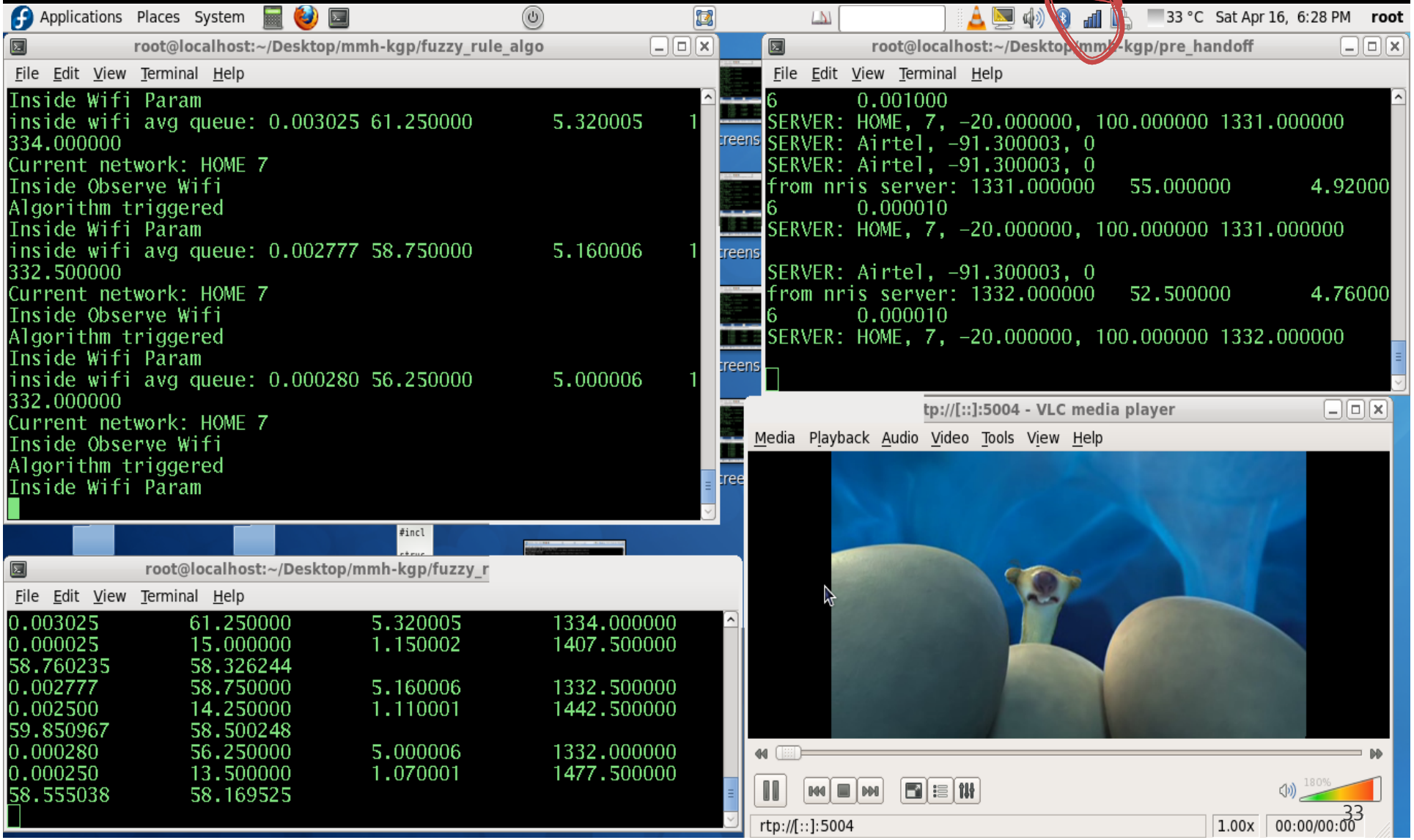
3G to WiFi-Before Handoff



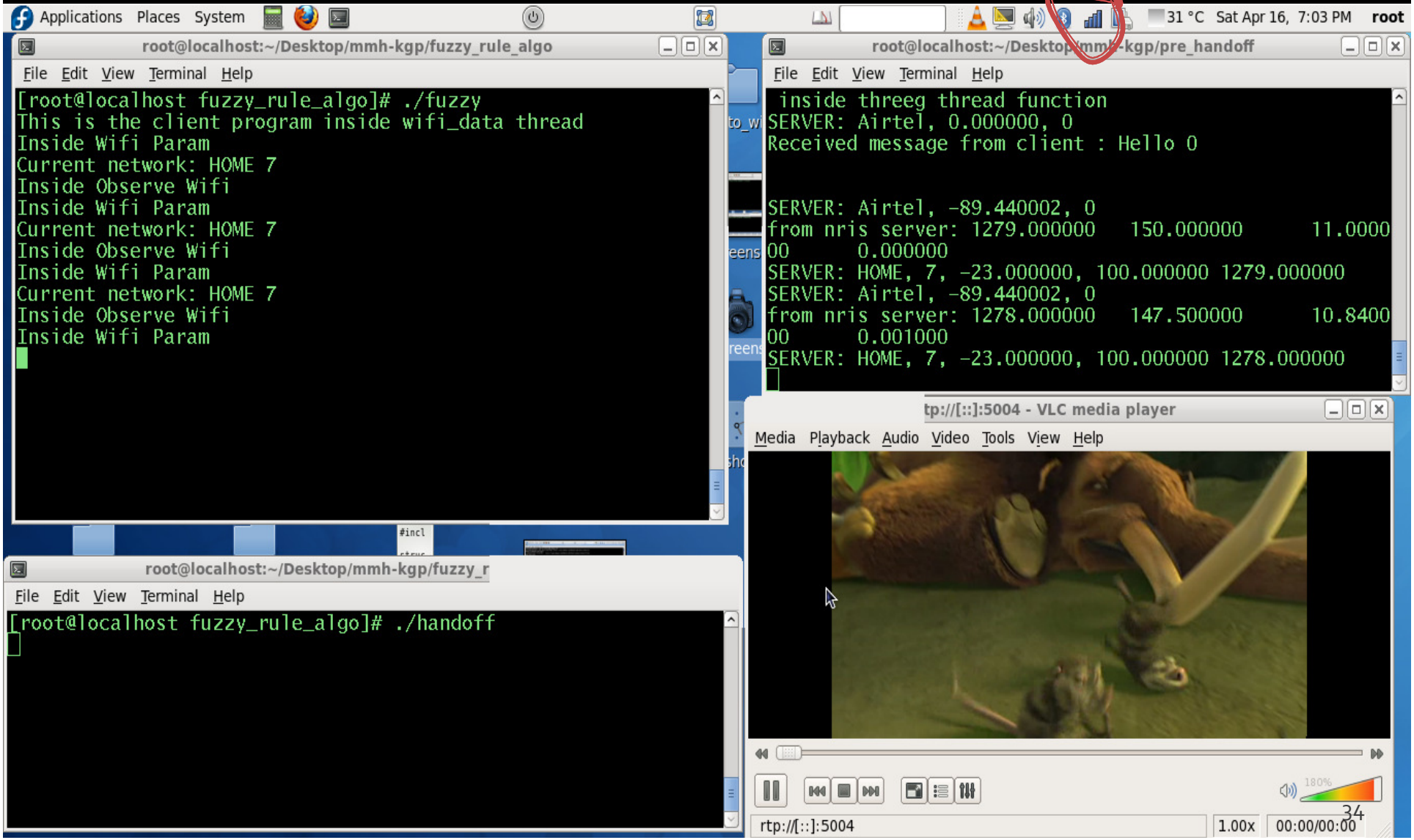
3G to WiFi-During Handoff



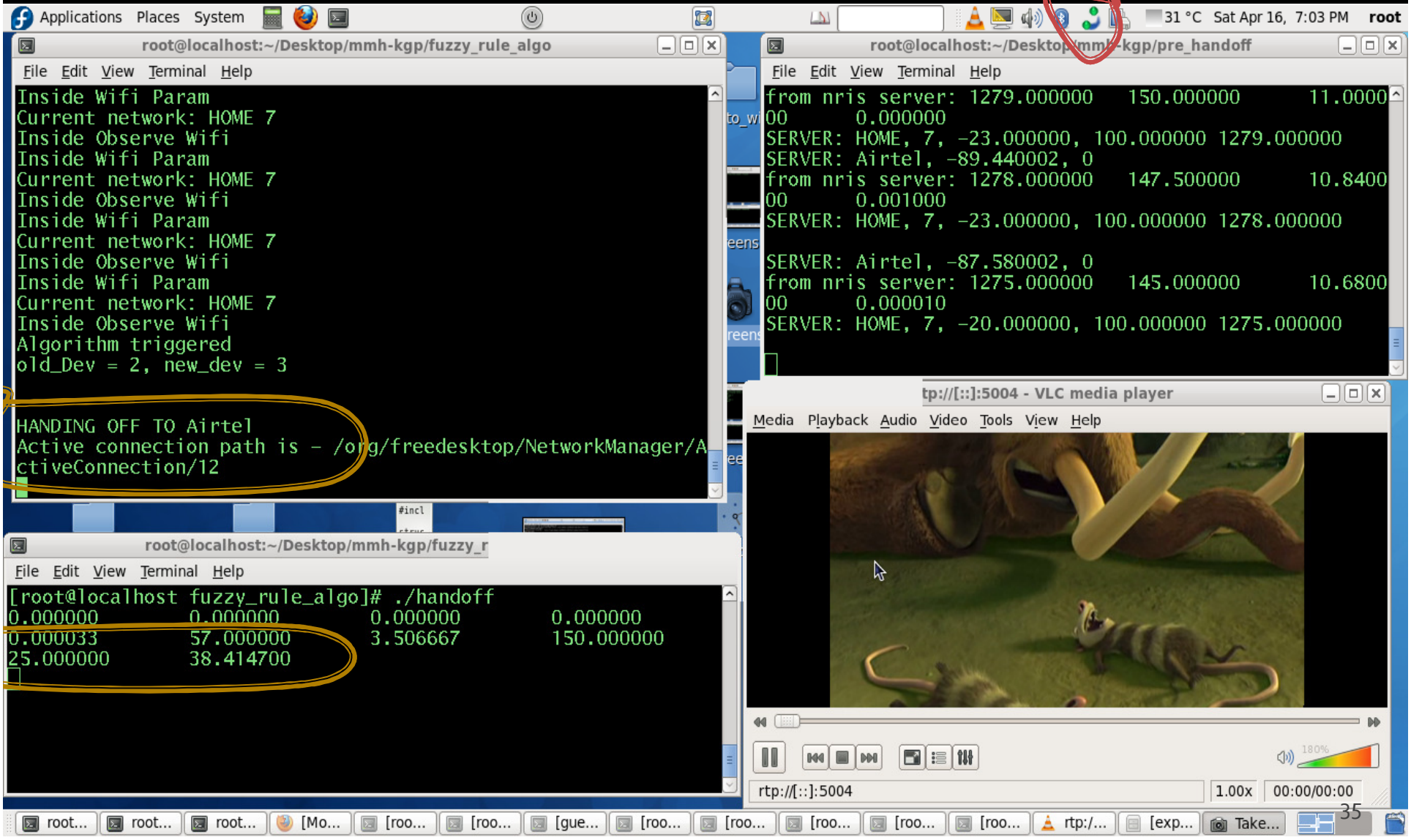
3G to WiFi-After Handoff



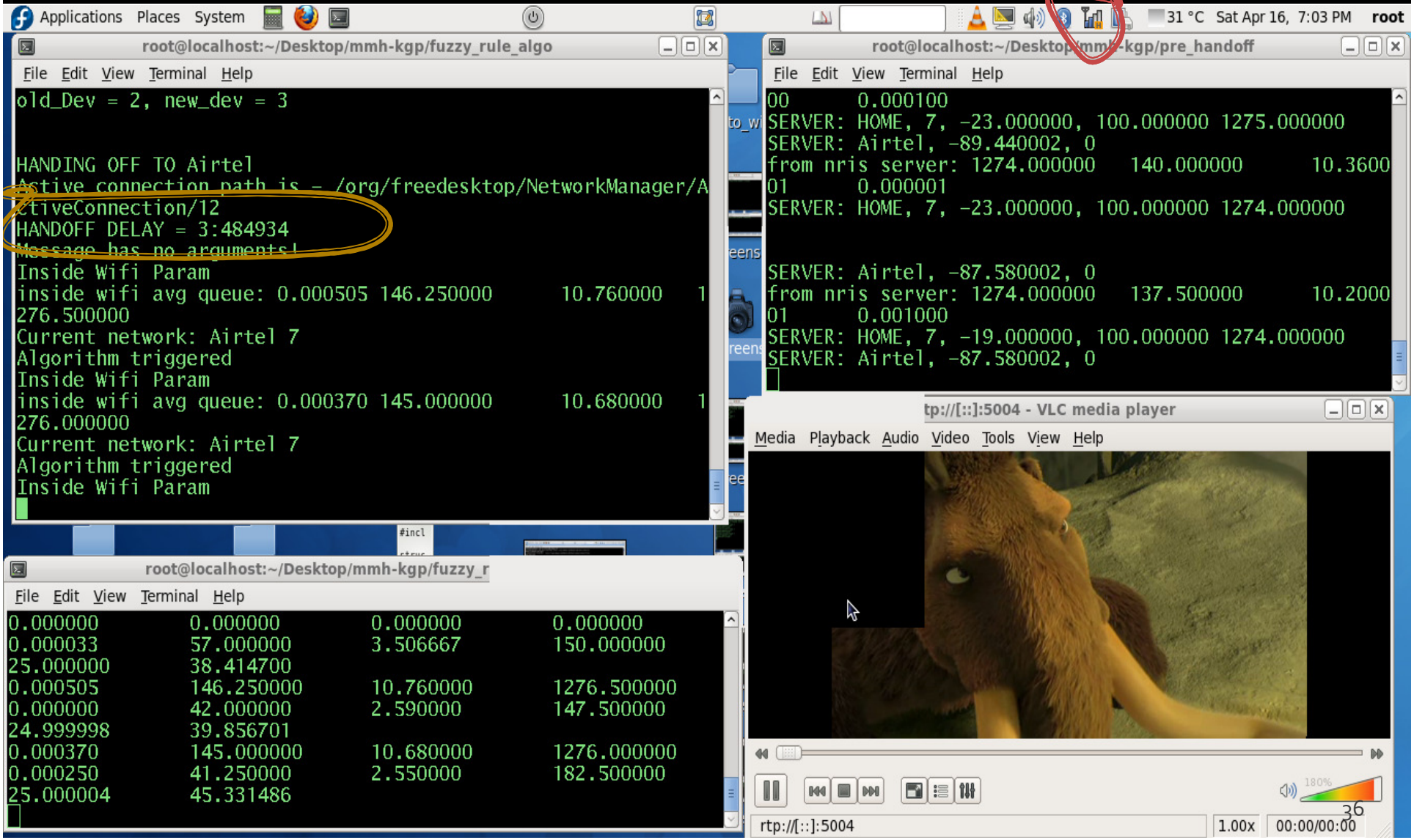
WiFi to 3g-Before Handoff



WiFi to 3g-During Handoff



WiFi to 3g-After Handoff



Issues addressed and observations

- Focused on a QoS aware fuzzy rule based algorithm that makes a multi-criteria based decision considering the *available bandwidth*, *end-to-end delay*, *jitter* and *bit error rate* of the networks, for a variety of traffic classes.
- Obtaining the QoS Parameters for applications before making the connection to a new network.
- Handoff delay from 3G to WiFi is 6sec and from WiFi to 3G is 3sec observed.
- Running Mobile IP protocols at both client side and server side.

Acknowledgment

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- We would like to thank the team of Mohammad Rafiq, Seema Kumar, Nagaraj Kammar, Guru Prasad,Gopi Krishna S Garge, Anand SVR, and Malati Hegde, Dept. of Electrical Communication Engg., Indian Institute of Science Bangalore for providing the mobile IP testbed and for the wonderful support received during the period.


QUESTIONS?


Thank You

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