

Energy Aware Scheduling and Queue Management for Next Generation Wi-Fi Routers

Husnu S. Narman

Mohammed Atiquzzaman

School of Computer Science
University of Oklahoma, USA.

husnu@ou.edu

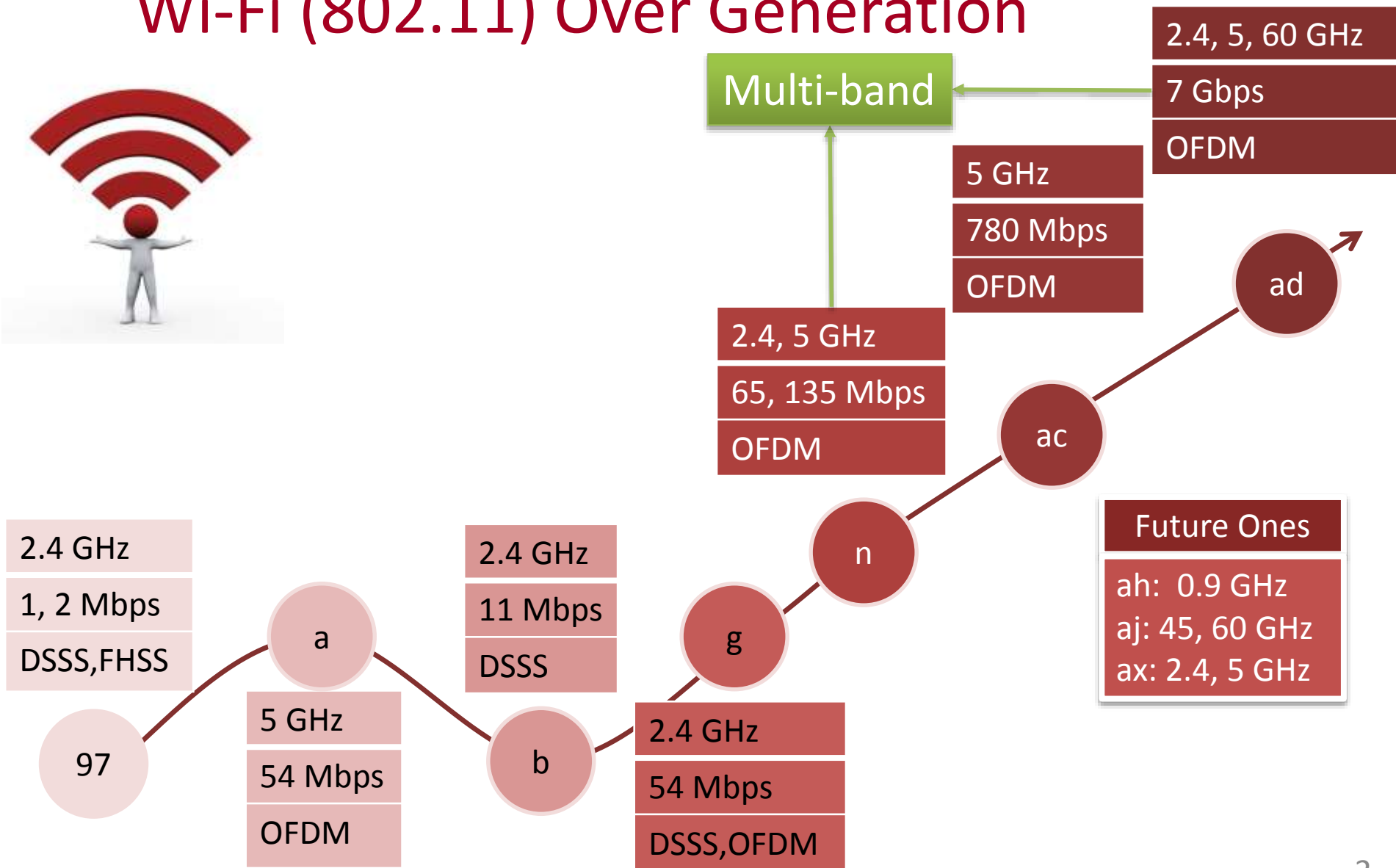
<http://students.ou.edu/N/Husnu.S.Narman-1>



Outline

- Introduction
- Multi Band Router Architecture
- Energy Aware Algorithm
- Results
- Conclusion

Wi-Fi (802.11) Over Generation



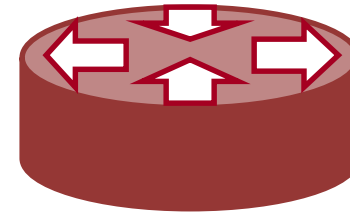
Current Multi Band (802.11n generation)



1st Band: 2.4 GHz



2nd Band: 5 GHz



The benefit of using multi-band router is less interference, higher capacity and better reliability.

Current Multi-Band Queuing System

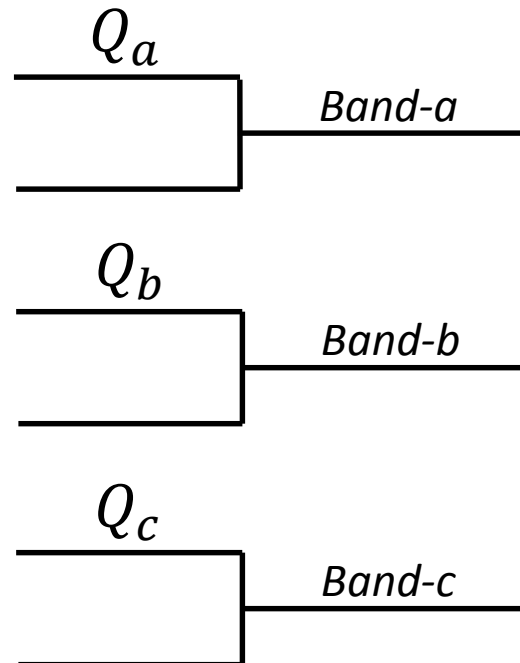
Introduction

Multiband

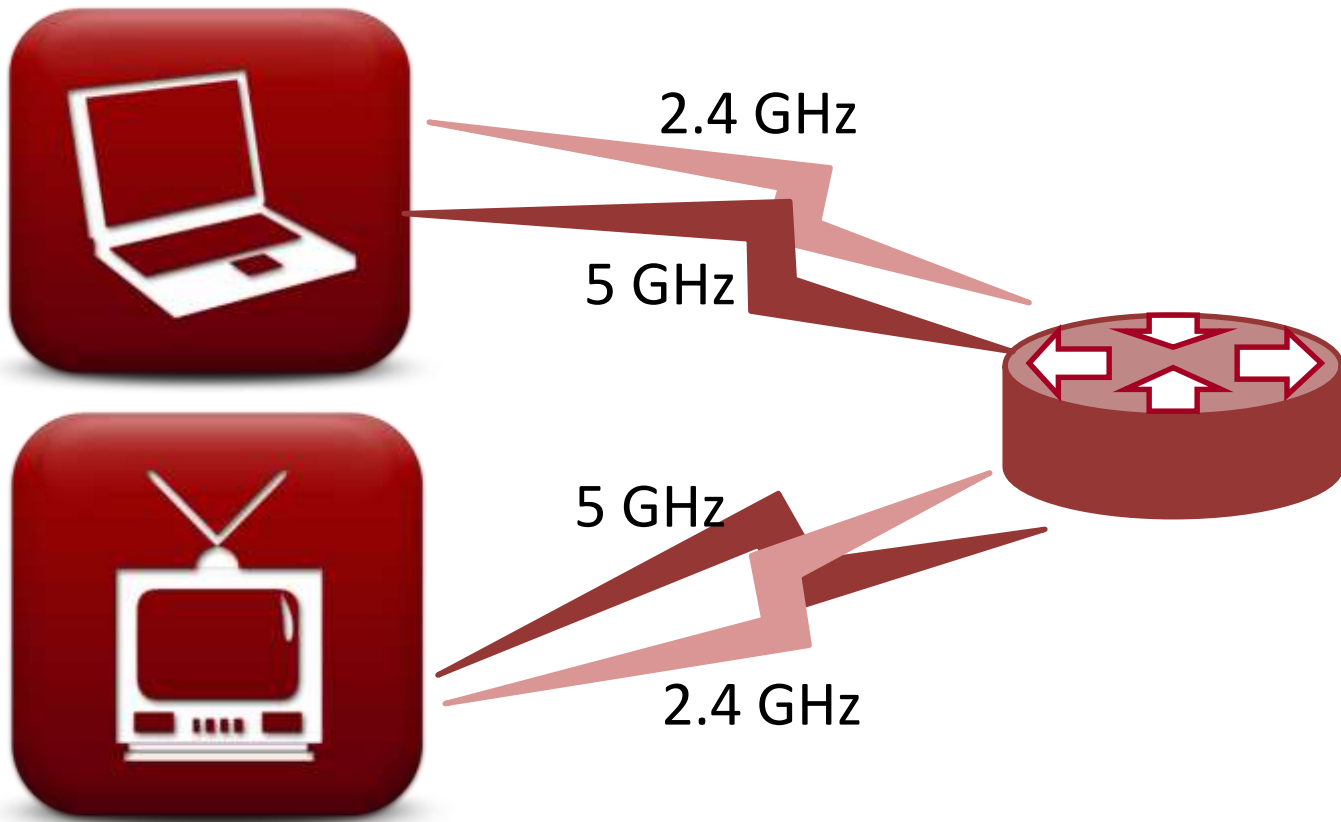
Energy

Result

Conclusion



Multi-shared-band Router (Suggested)



Multi-shared-band Queuing System

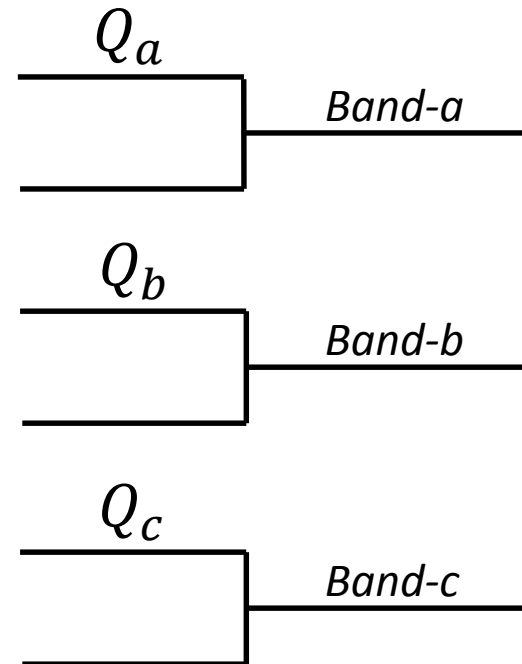
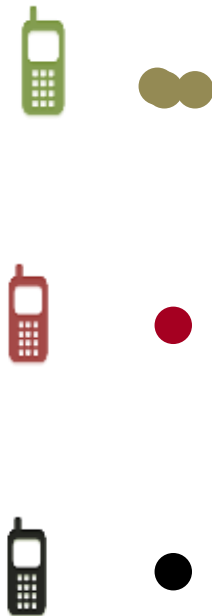
Introduction

Multiband

Energy

Result

Conclusion



Current Multi-band and Multi-shared-band Routers

- **Energy consumption** is high
 - \$27 per year for a router even for stand by (Ecotricity)



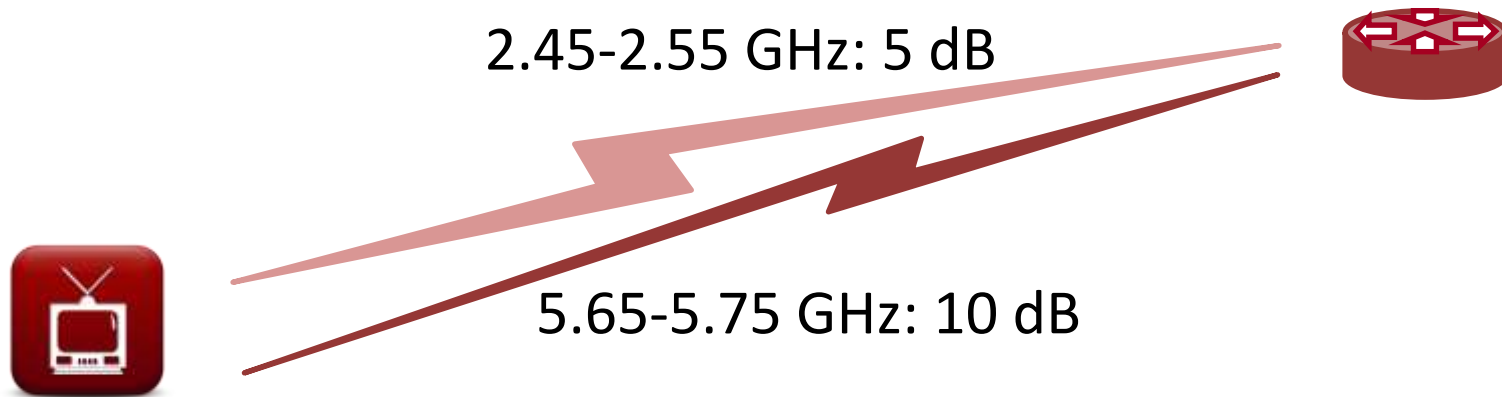
Objective



Decreasing energy consumption of multi-band routers.

Current Solution for Energy Awareness

- Channel selection based on power consumption by considering QoS.



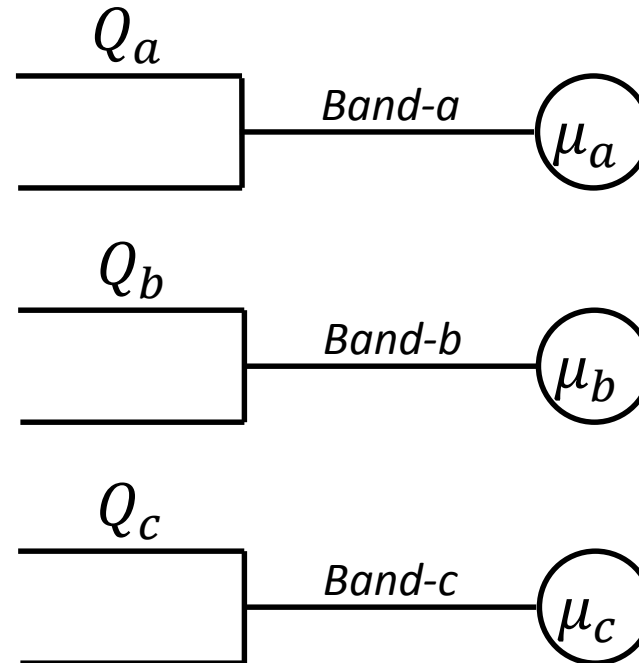
- User has Antenna Selection in MIMO
 - Good for transferring data but **not for stand by.**
- Using small packets

Proposed: Energy Aware Scheduling Algorithm and Queue Management (e-ASA)



- Follows **sleep and wake-up** procedure of bands
- Depends on **incoming traffic rates and QoS**

e-ASA Based Multi-shared-band Queuing System



e-ASA Based Multi-shared-band Scheduling

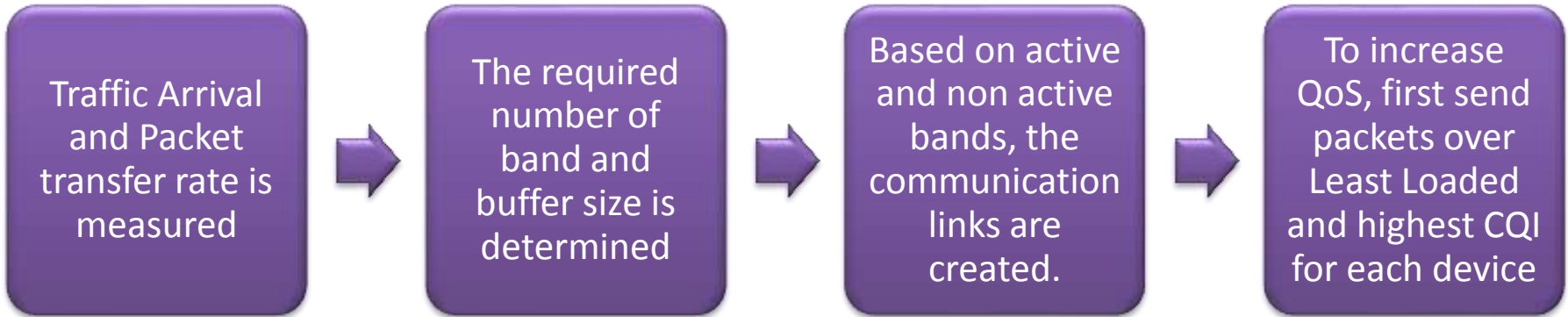
Introduction

Multiband

Energy

Result

Conclusion



λ and μ

$$D = \rho^N \frac{1 - \rho}{1 - \rho^{N+1}}$$

$$\gamma = 1 - D$$

Expected throughput rate

- Coverage
- Exp. throughput

- Packet Trans.

Energy Modeling

- Energy modelling for only downloading
- Depends on **idle or busyness of bands**

Energy consumption during idle time

$$E_a = T * (\alpha * \rho_a + \beta * (1 - \rho_a))$$

Simulation time

Energy consumption during data transfer time

Band is busy

Band is idle

$$E = E_a + E_b + E_c$$

Total energy consumption

Simulation Environments



Used Bands	≙	2.4GHz, 3.6GHz, 5GHz
Length of Q_s	≙	150 packets
Length of Q_a , Q_b and Q_c	≙	50 packets
Bandwidth size on each bands	≙	20MHz
Modulations	≙	QPSK, 16QAM, and 64QAM
Channel Quality Index (CQI)	≙	3, 5, 7, and 11
Transmission Time Interval	≙	1ms
Threshold for one band	≙	0.8
Threshold for two bands	≙	0.9
α and β	≙	10 and 3, respectively

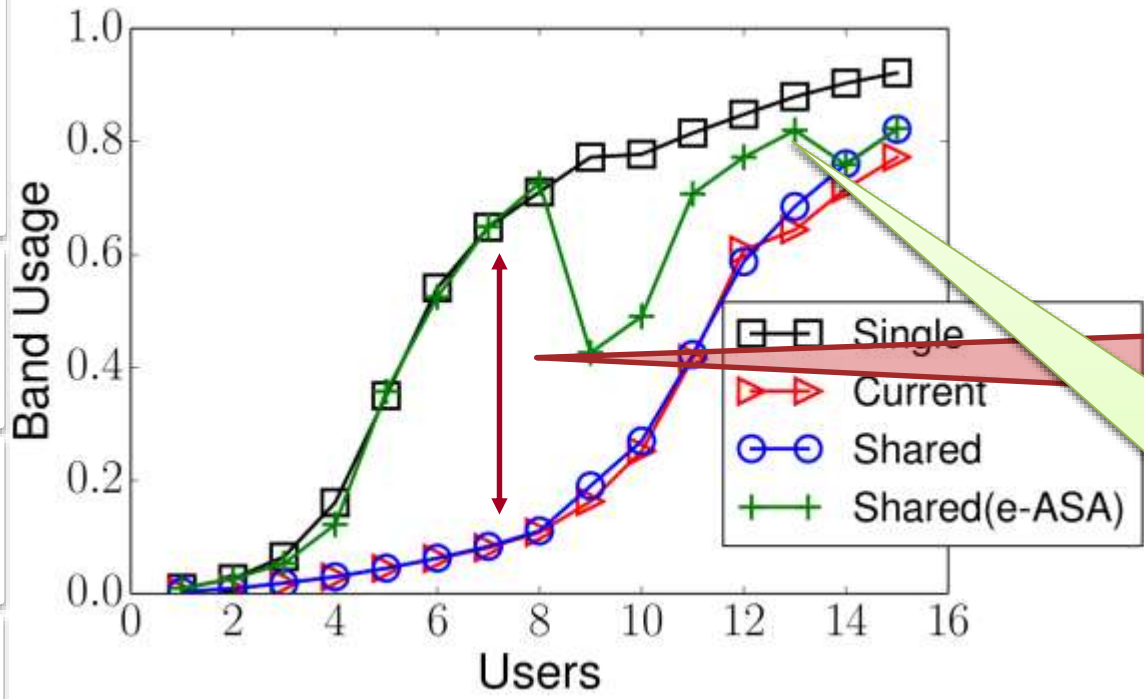
Results



- Discrete event simulation by following $M/M/3/N$.
- 100 realizations for different number of users with increasing data traffic.
- We compare
 - Single (Single band router),
 - **Current** (Current multi band router),
 - **Shared** (Multi-shared-band router)
 - **Shared (e-ASA)** (Multi-shared-band with energy aware scheduling algorithm)

- Introduction
- Multiband
- Energy
- Result
- Conclusion

Band Usage



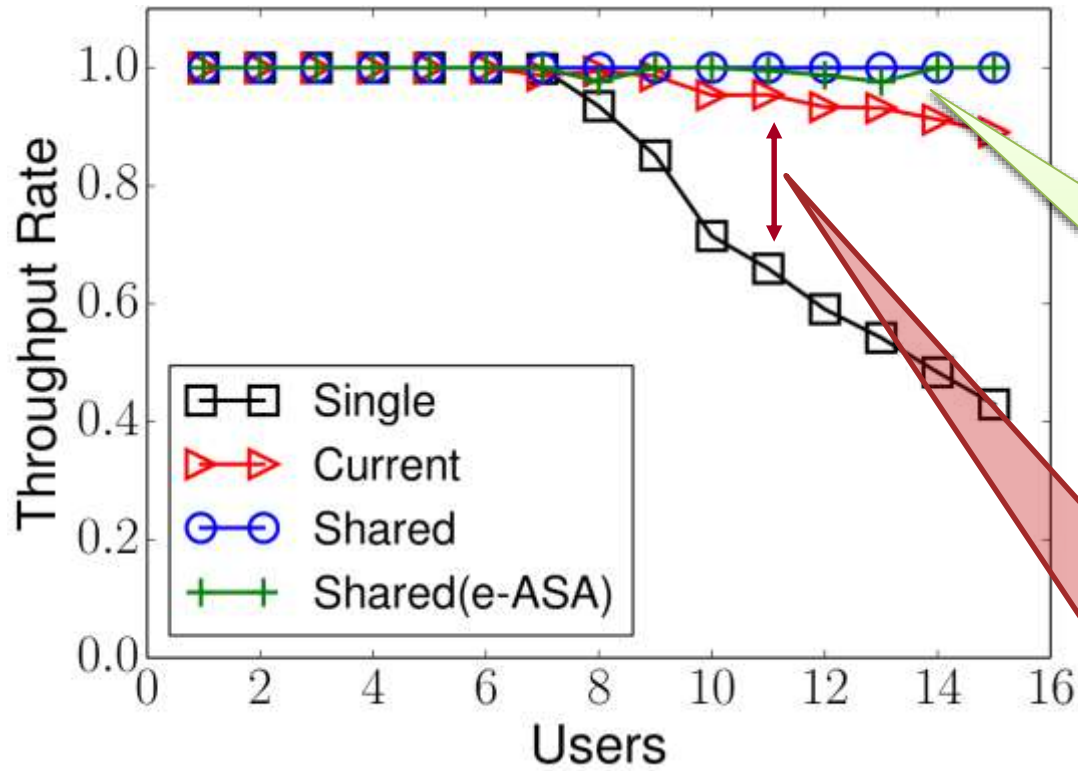
Objective
Observing effects of number of users on band usage of all bands.

Band Usages of Single and e-ASA are same and lower than multi-band routers.

Band Usages of e-ASA is changeable because of dynamic allocation.

Band usages of multi-band routers are lower.

Throughput Rate



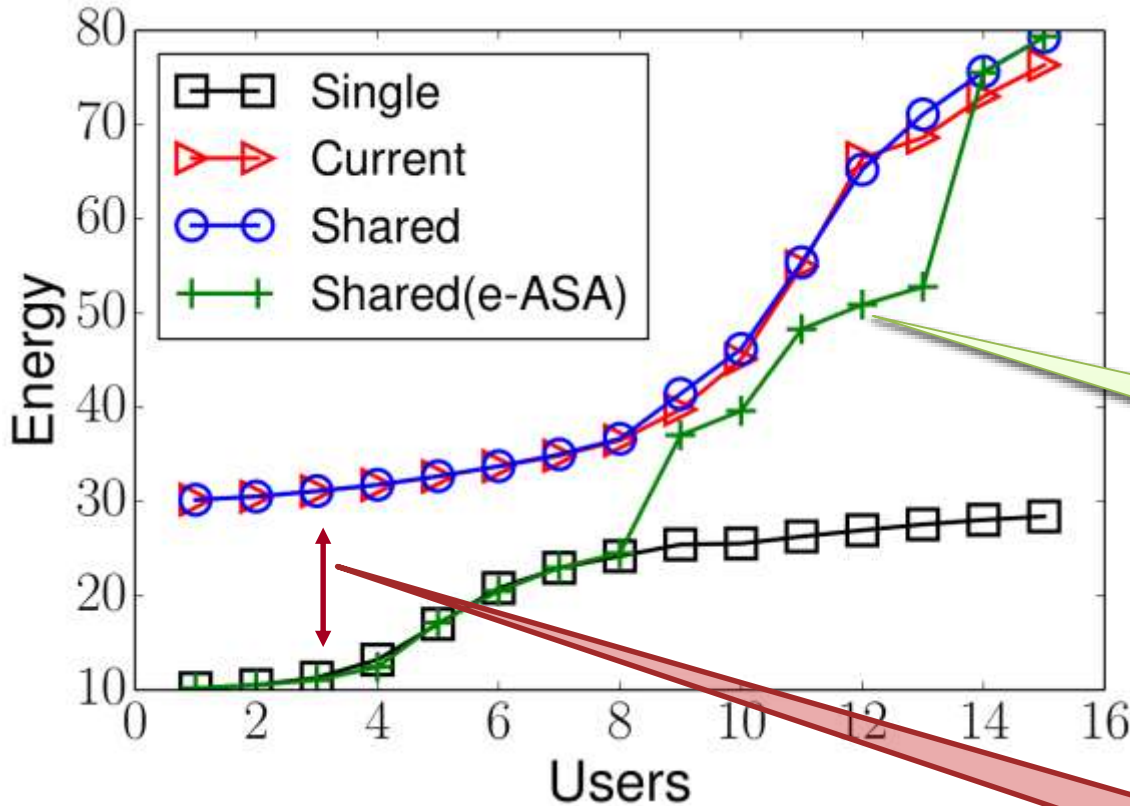
Objective
 Observing effects of number of users on throughput rate.

Throughput rate of e-ASA and shared are higher than other cases.

Throughput rate of single are lower.

e-ASA does not decrease the throughput rate comparing to multi-shared-band.

Energy Consumption



Objective
 Observing effects of number of users on energy usage.

Energy consumption of e-ASA is increasing because of number of users.

Energy consumption of e-ASA is lower than other multi-band routers except when three bands are fully used.

Energy usage of e-ASA and single are same for low number of users.

Summary of Results



20%

Improving throughput rate of multi-band up to 20%

Multi-shared-band with e-ASA



60%

Up to 60% energy can be saved by using e-ASA.



Conclusion

Introduction

Multiband

Energy

Result

Conclusion

Thank You



<http://students.ou.edu/N/Husnu.S.Narman-1>
husnu@ou.edu