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

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Outline

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

Wi-Fi (802.11) Over Generation

97

2.4 GHz
1, 2 Mbps
DSSS,FHSS

a

5 GHz
54 Mbps
OFDM

2.4 GHz
11 Mbps
DSSS

b

g

2.4 GHz
54 Mbps
DSSS,OFDM

n

2.4, 5 GHz
65, 135 Mbps
OFDM

Multi-band

5 GHz
780 Mbps
OFDM

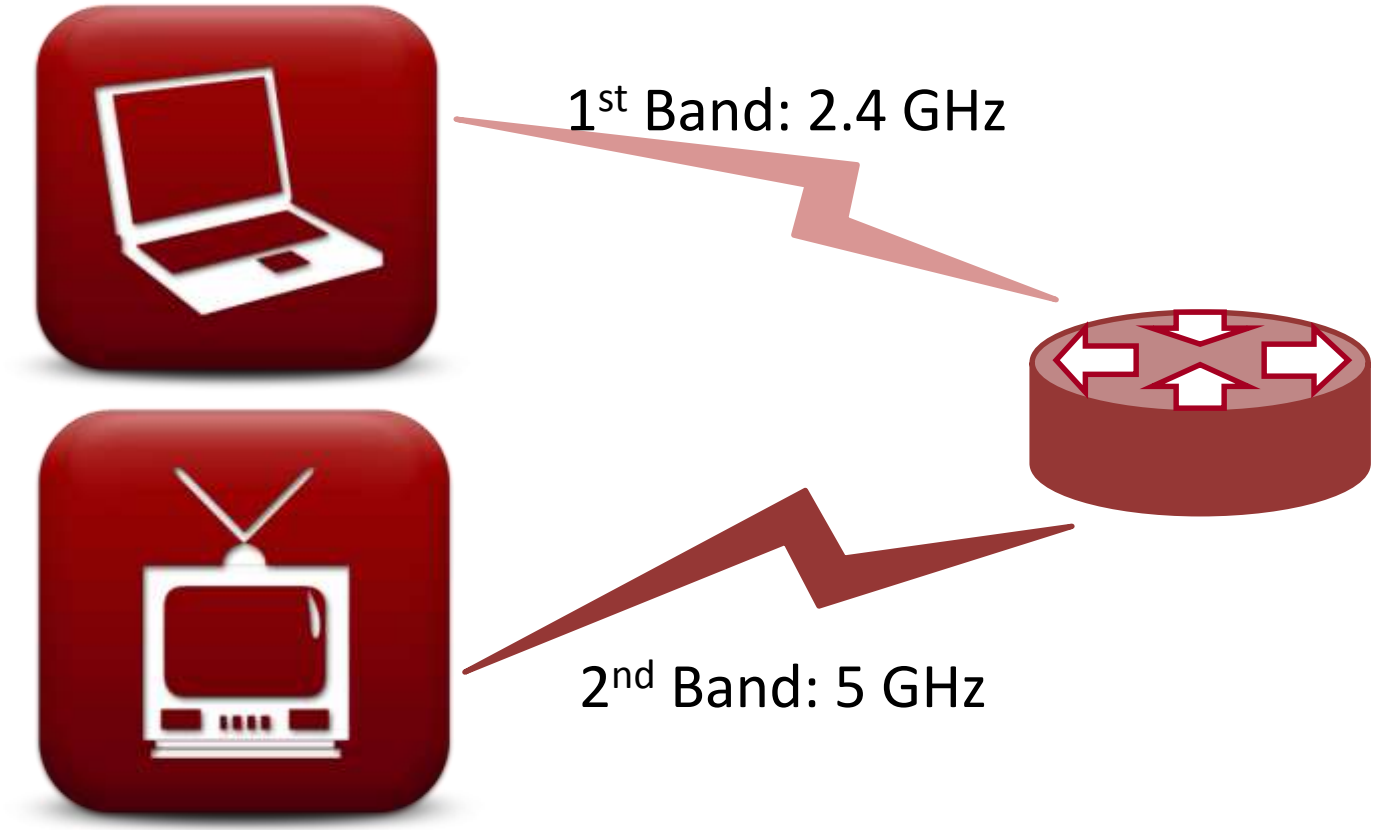
ac

2.4, 5, 60 GHz
7 Gbps
OFDM

ad

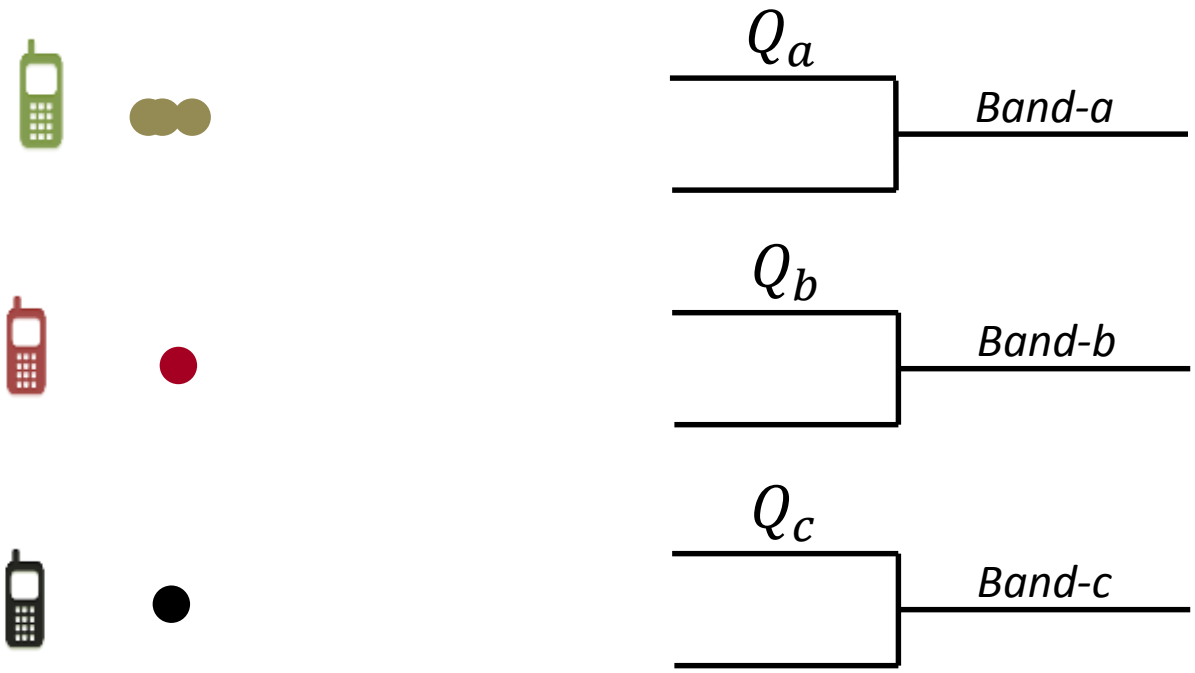
Future Ones
ah: 0.9 GHz
aj: 45, 60 GHz
ax: 2.4, 5 GHz

Current Multi Band (802.11n generation)

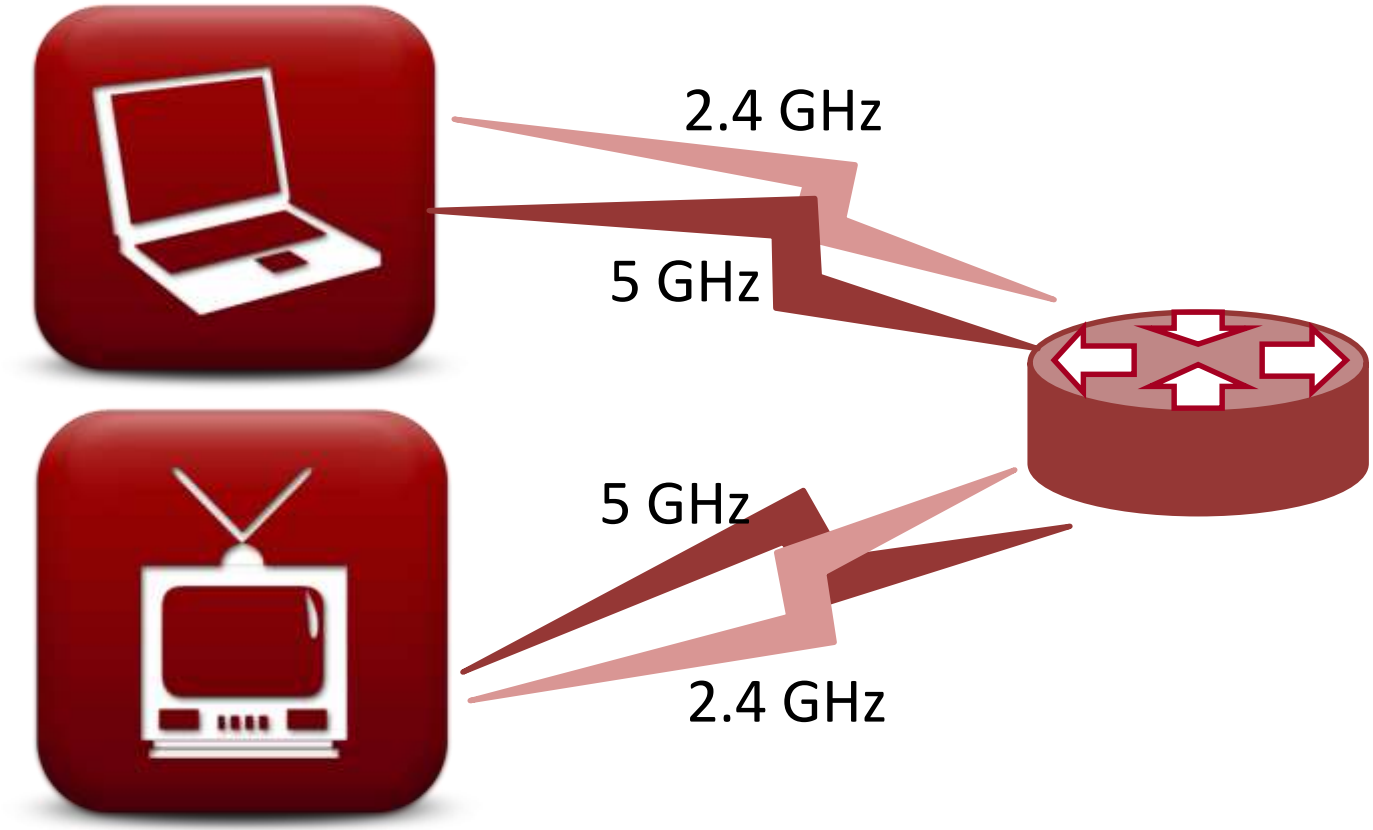


The benefit of using multi-band router is less interference, higher capacity and better reliability.

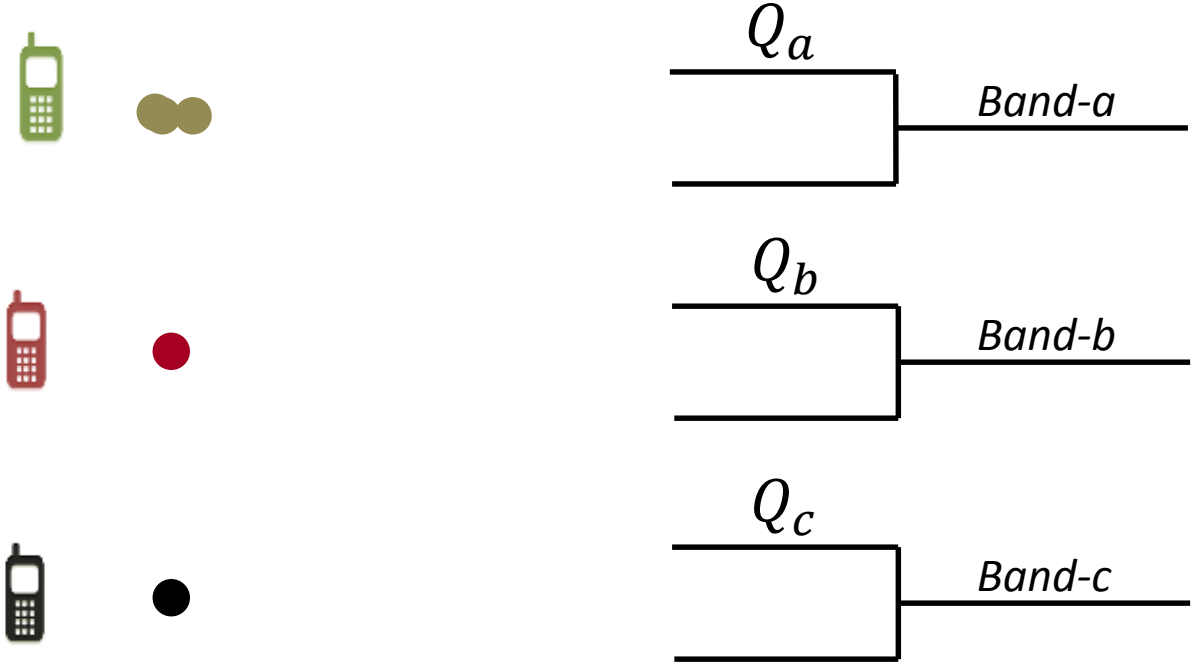
Current Multi-Band Queuing System



Multi-shared-band Router (Suggested)



Multi-shared-band Queuing System



Current Multi-band and Multi-shared-band Routers

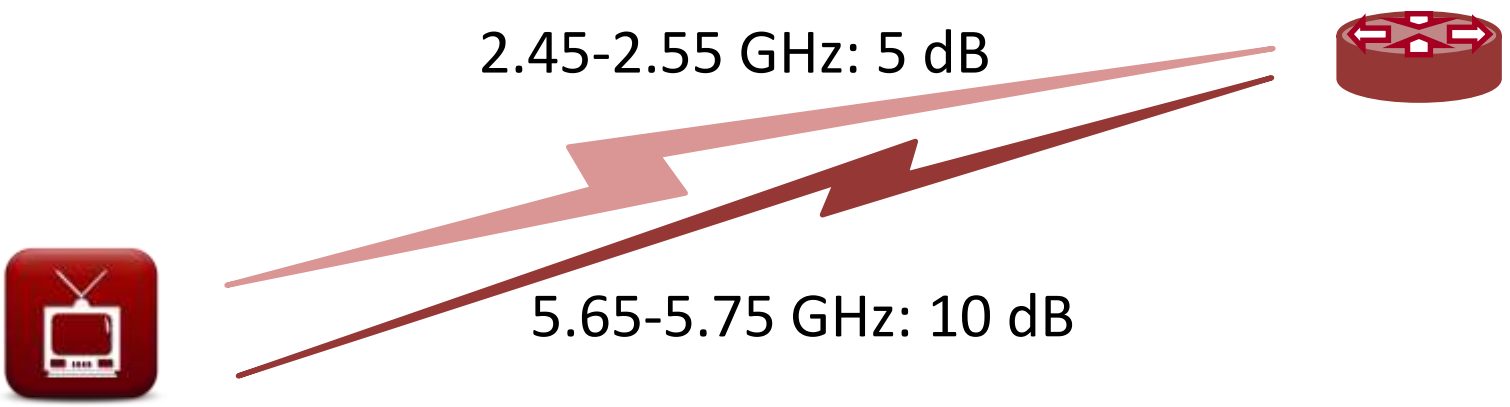
- Energy consumption is high
  - $27 per year for a router even for stand by (Ecotricity)

Objective

Decreasing energy consumption of multi-band routers.

Current Solution for Energy Awareness

- Channel selection based on power consumption by considering QoS.

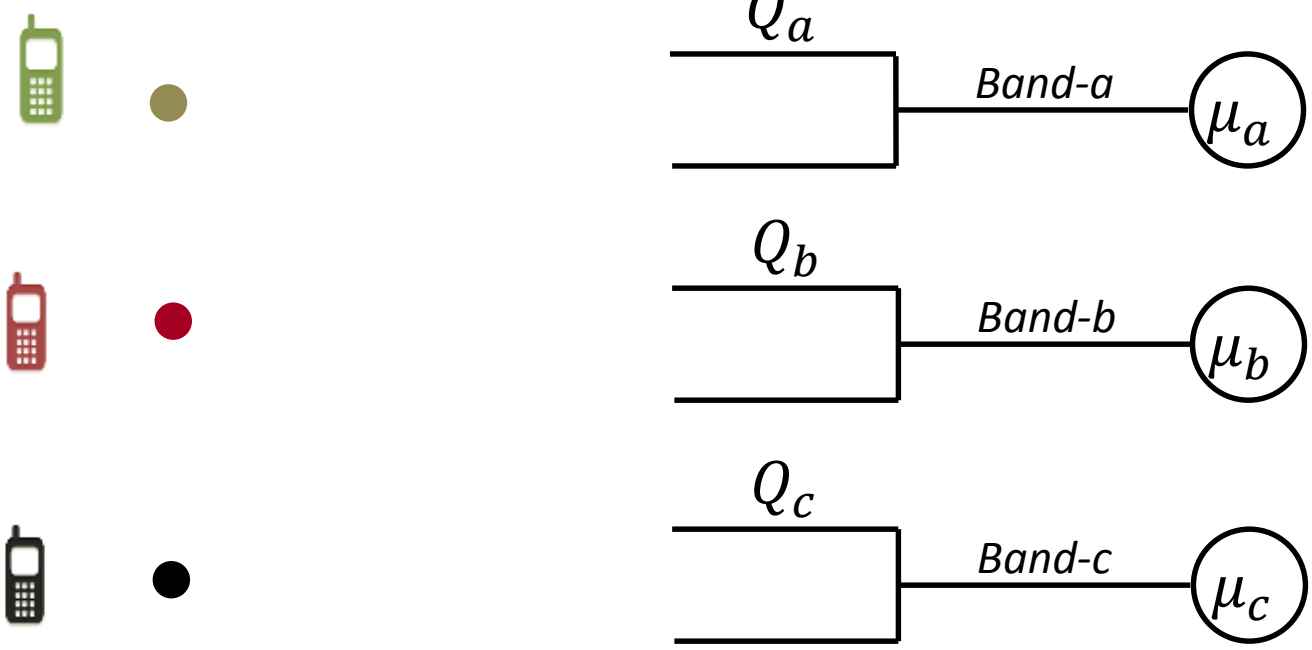


- User has Antenna Selection in MIMO
  - Good for transferring data but not for stand by.
- Using small packets

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

Traffic Arrival and Packet transfer rate is measured

The required number of band and buffer size is determined

Based on active and non active bands, the communication links are created.

To increase QoS, first send packets over Least Loaded and highest CQI for each device

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

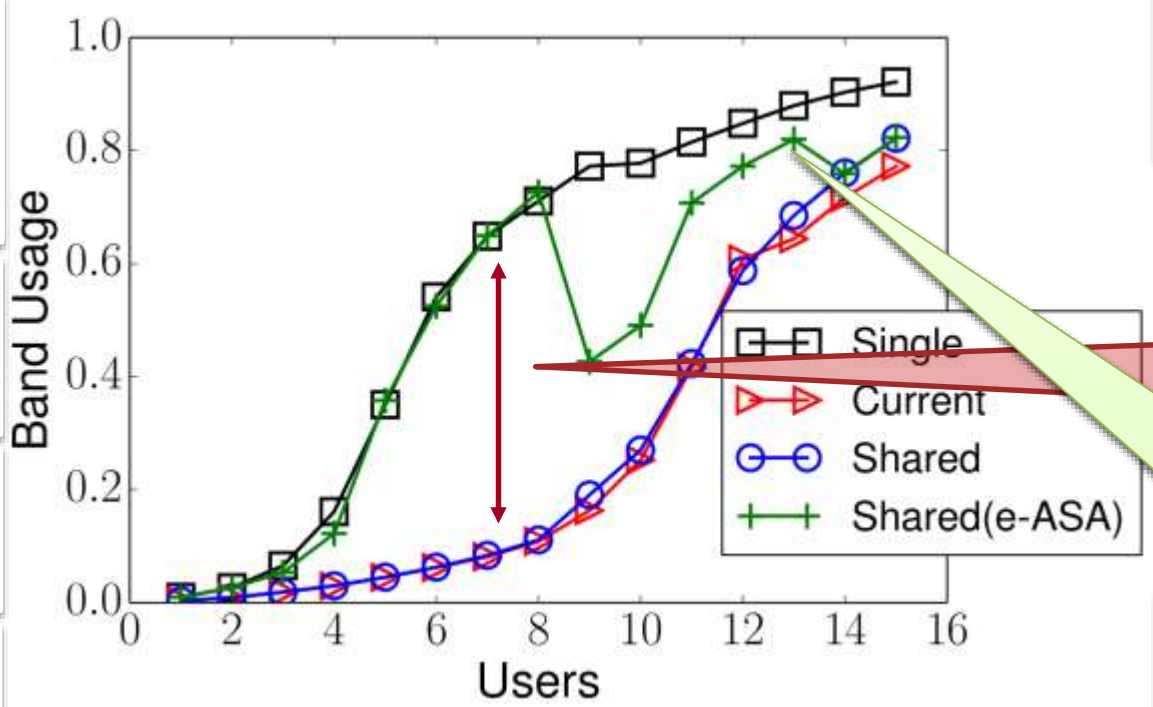
Simulation Environments

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

Band Usage



Objective

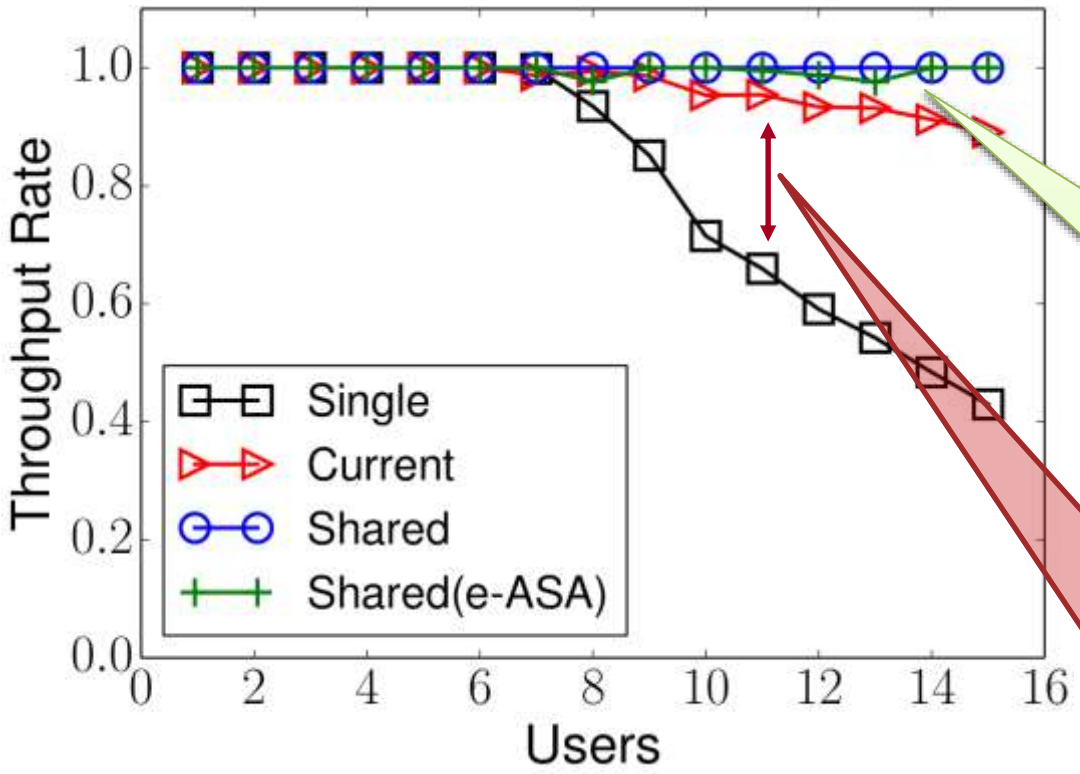
Observing effects of number of users on band usage of all bands.

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

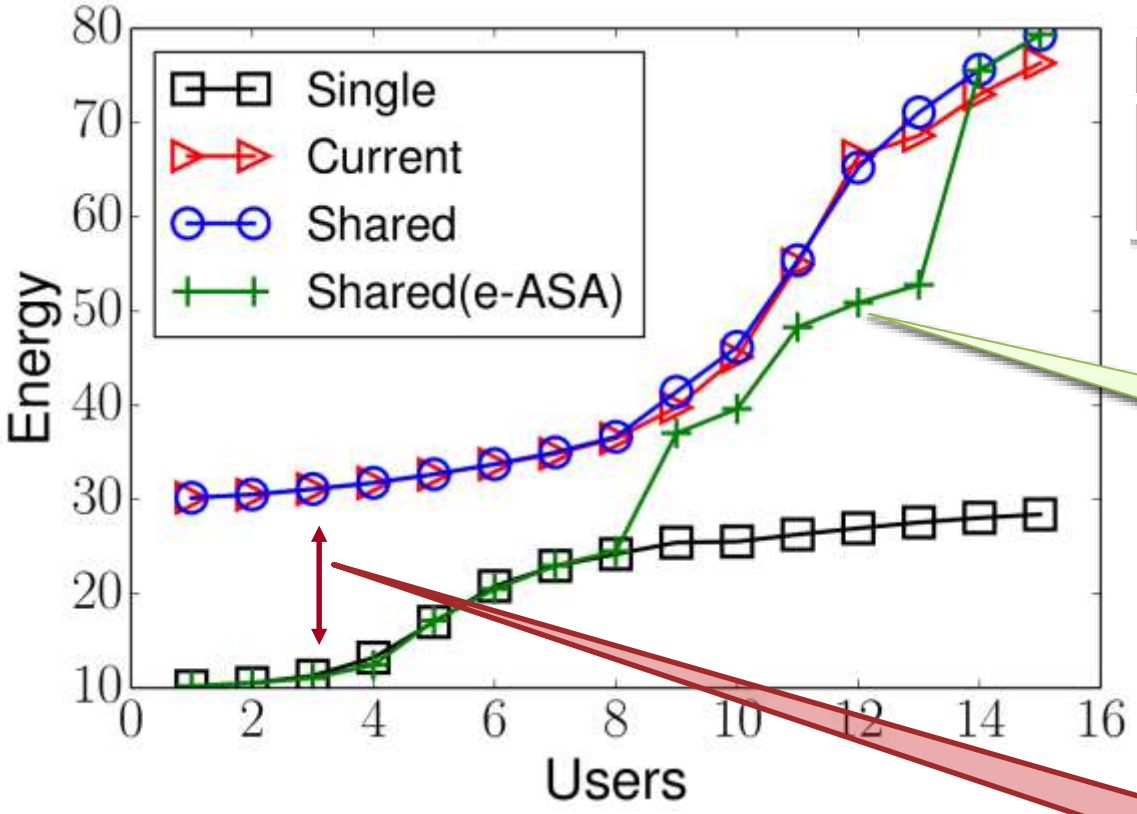
Observing effects of number of users on throughput rate.

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

Improving throughput rate of multi-band up to 20%

Multi-shared-band with e-ASA

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

Conclusion

Thank You

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