A DYNAMIC LINK AGGREGATION SCHEME FOR HETREGENOUS NETWORKS

Bala Murali Krishna , Madhuri Siddula , Vanlin Sathya and Bheemarjuna Reddy Tamma

Networked Wireless Systems Laboratory,

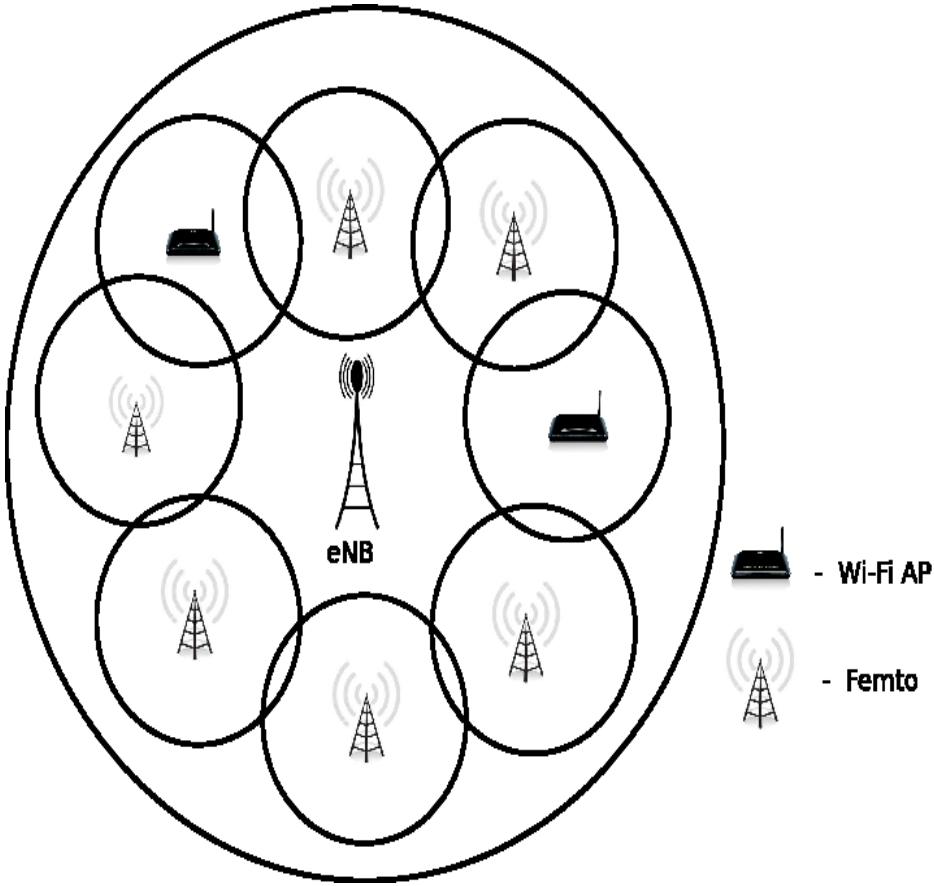
Dept. of Computer Science and Engineering,

Indian Institute of Technology (IIT) Hyderabad, India

Introduction to Hetrogenous Networks

IIT Hyderabad

- In future 60% of total cellular traffic is contributed through indoor users.
- End-users install small base stations (a.k.a. Femto cell nodes, Wi-Fi Access Points) inside their homes/offices.
- Heterogeneous Network (HetNet) is a collective deployment of various technologies like LTE Femtos, Wi-Fi Acess Points (APs) and LTE Macros.
- User Equipments (UEs) like laptops, tablets, smart phones come with multiple radio interfaces to have various connectivity options.



Issue and Challenges

IIT Hyderabad

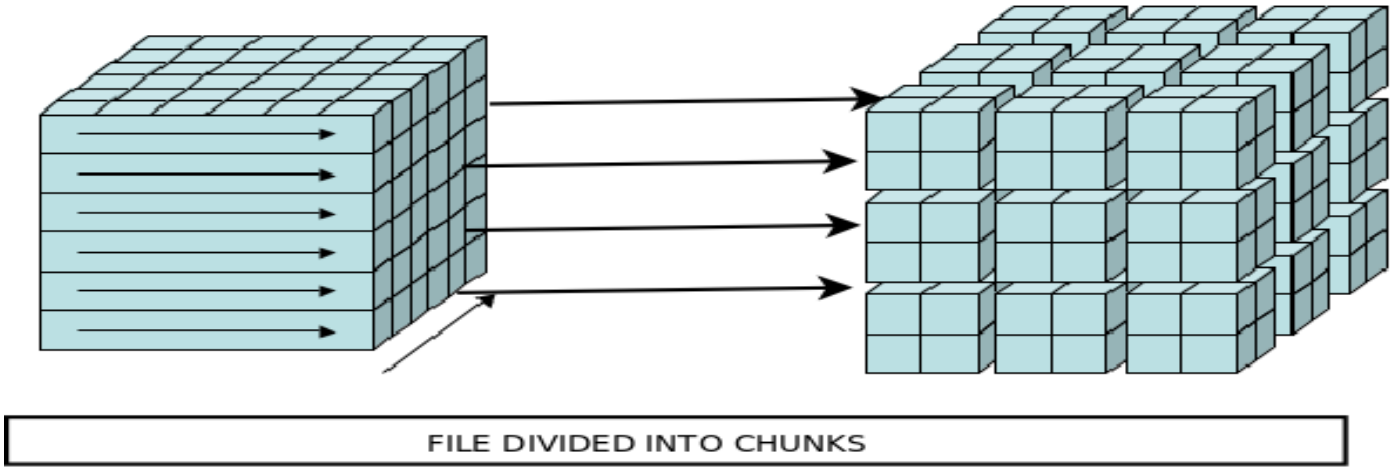
- Applications are not designed to take advantage of multiple interfaces.
- Only one interface will be kept active at a time.
- Inefficient usage of resources.
- Dynamics of changing network scenarios are not considered.

Related Work:

Application-level link aggregation (ALA) scheme demonstrates link aggregation over two Wi-Fi interfaces.

T. Takiguchi, A. Hidaka, H. Masui, Y. Sugizaki, O. Mizuno, and K. Asatani, "A new application-level link aggregation and its implementationon android terminals," Wireless Communications and Mobile Computing, vol. 12, no. 18, pp. 1664–1671, 2012.

- Peer-to-peer Bit-Torrent applications use a method called chunking to split the file for efficient delivery.



Proposed Work

- Dynamic link aggregation Scheme (DLAS) is introduced to efficiently use multiple networks for the file transfer in the HetNet deployment made by telecom operator.

- Considers time varying link capacities and provides fairness to legacy flows.

- Network congestion is taken into consideration for dynamically changing the number of chunks being transferred on each of the individual links.

- Two DLAS approaches have been introduced:
  1. Parallel DLAS
  2. Sequential DLAs

Proposed Work

- We define Chunk Level Instantaneous Throughput

$$Th_i(I_j) = N_{ch}(I_j) * Ch_{size}/RTD$$

where ***RTD*** is Round Trip Delay for ***N*** chunks of each size ***Ch***$_{size}$.

- Overall Throughput is given as

$$Th_{ov}(I_j) = \alpha * Th_{old}(I_j) + (1 - \alpha) * Th_i(I_j) \quad (\text{for } \alpha,\ 0 < \alpha < 1)$$

- Number of chunks requested on an interface is proportional to overall throughput obtained on that interface (as overall throughput reflects link capacity)

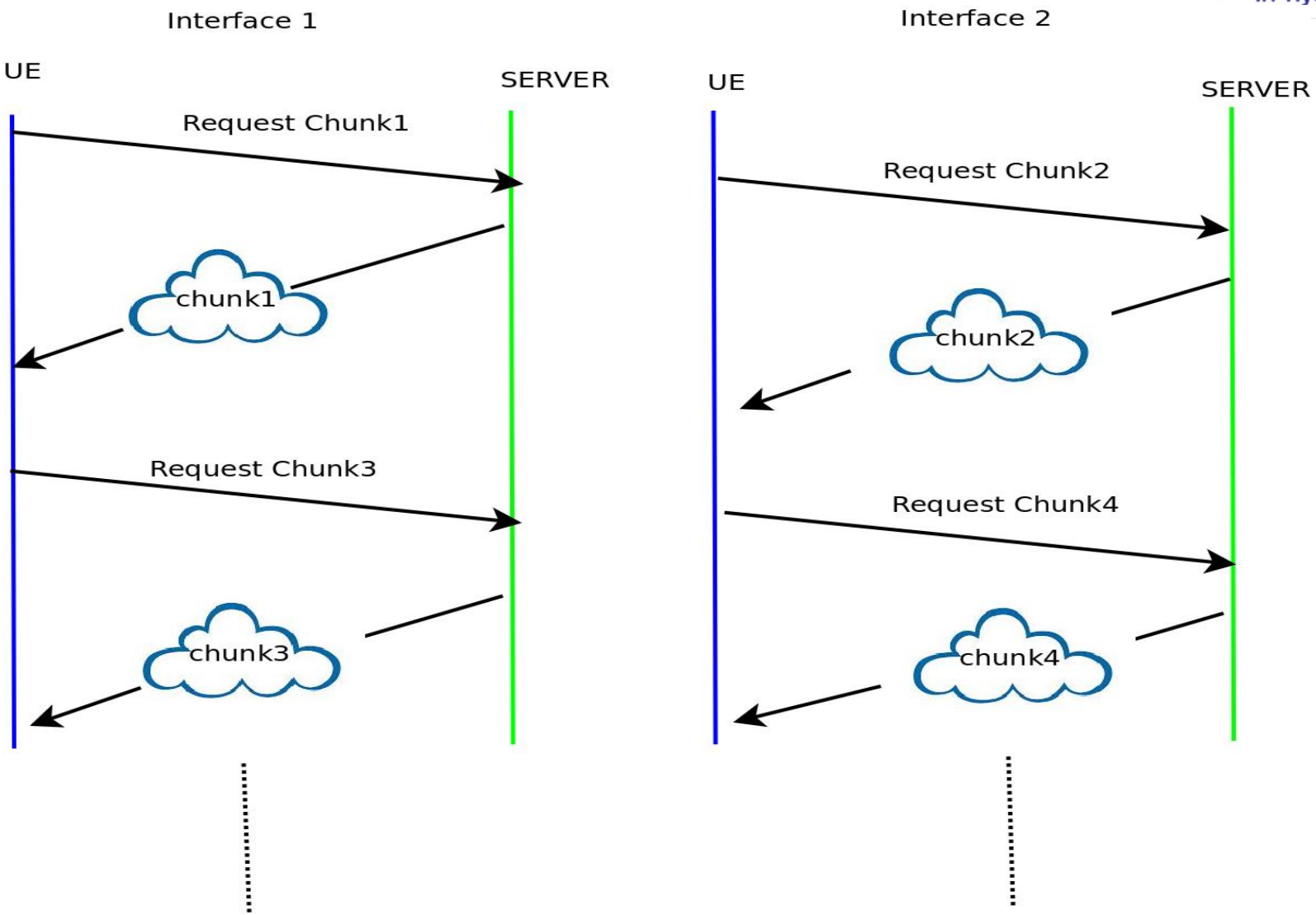
- Number of chunks requested on interfaces are given as

$$N_{ch}(I_1) : N_{ch}(I_2) : .. : N_{ch}(I_j) = Th_{ov}(I_1) : Th_{ov}(I_2) : .. : Th_{ov}(I_m)$$

SLAS Scheme

- Sequential approach deals with chunk level sequential transfer of flow's data at any given time instant on each link.
- UE requests for one or more chunks through each interface in a transmission round.
- Server responds by sending corresponding chunks.
- Only after receiving the requested chunks, UE calculates the instantaneous throughput obtained on each interface, which is further used in updating the value of overall throughput of the interface.

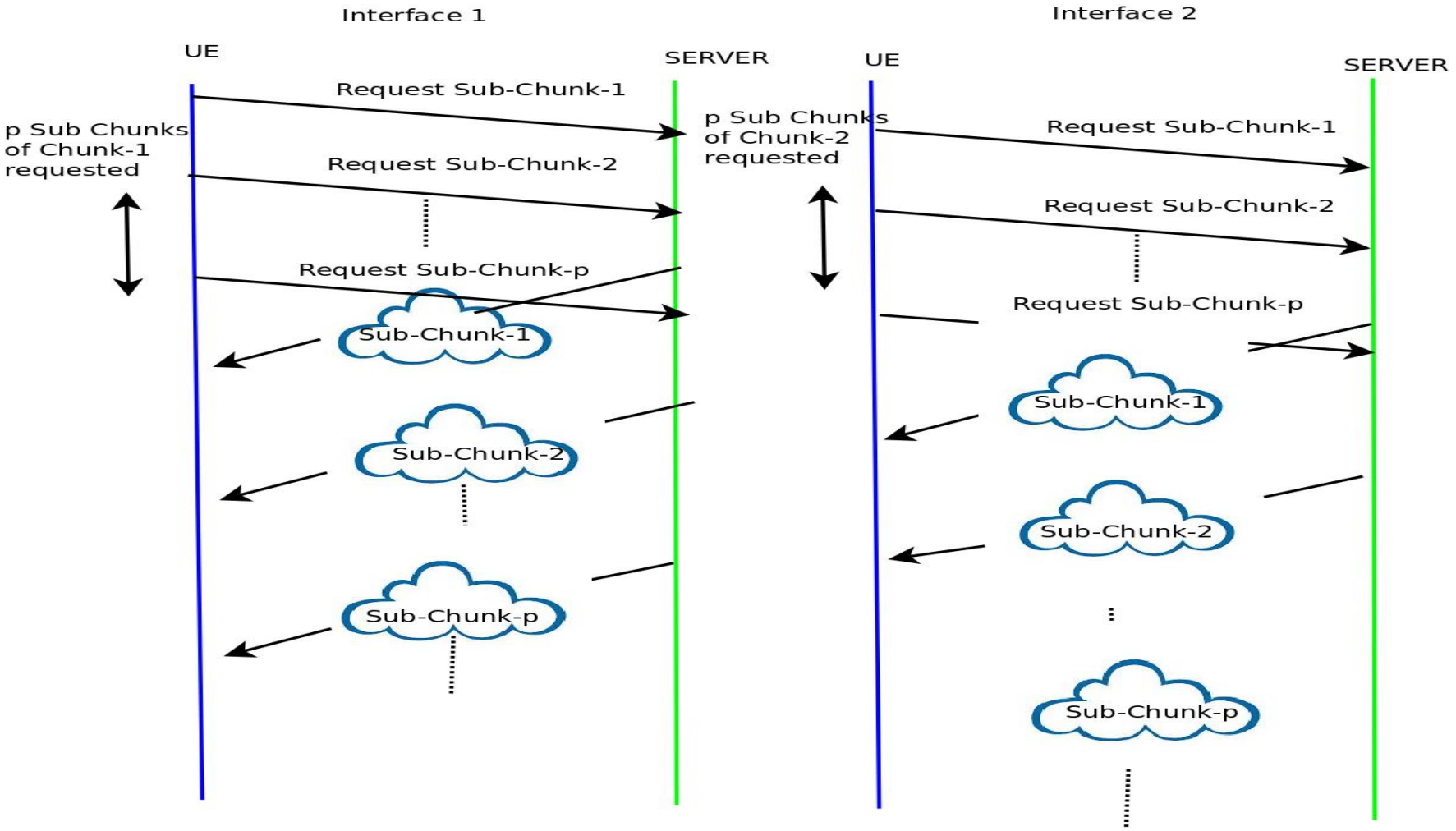
SLAS Scheme Example



PLAS Scheme

- Similar to Sequential DLAS, UE requests for one or more chunks through each interface and the server responds by sending corresponding chunks.
- Each chunk of size Ch_{size} is divided into p sub-chunks of size $Ch_{sm} = Ch_{size} / p$
- p number of parallel TCP flows (i.e., one for each sub-chunk of the chunk under consideration) established over each individual interface.
- Data transfer rate is high and there available bandwidth is more efficiently utilized in PLAS.

PLAS Example



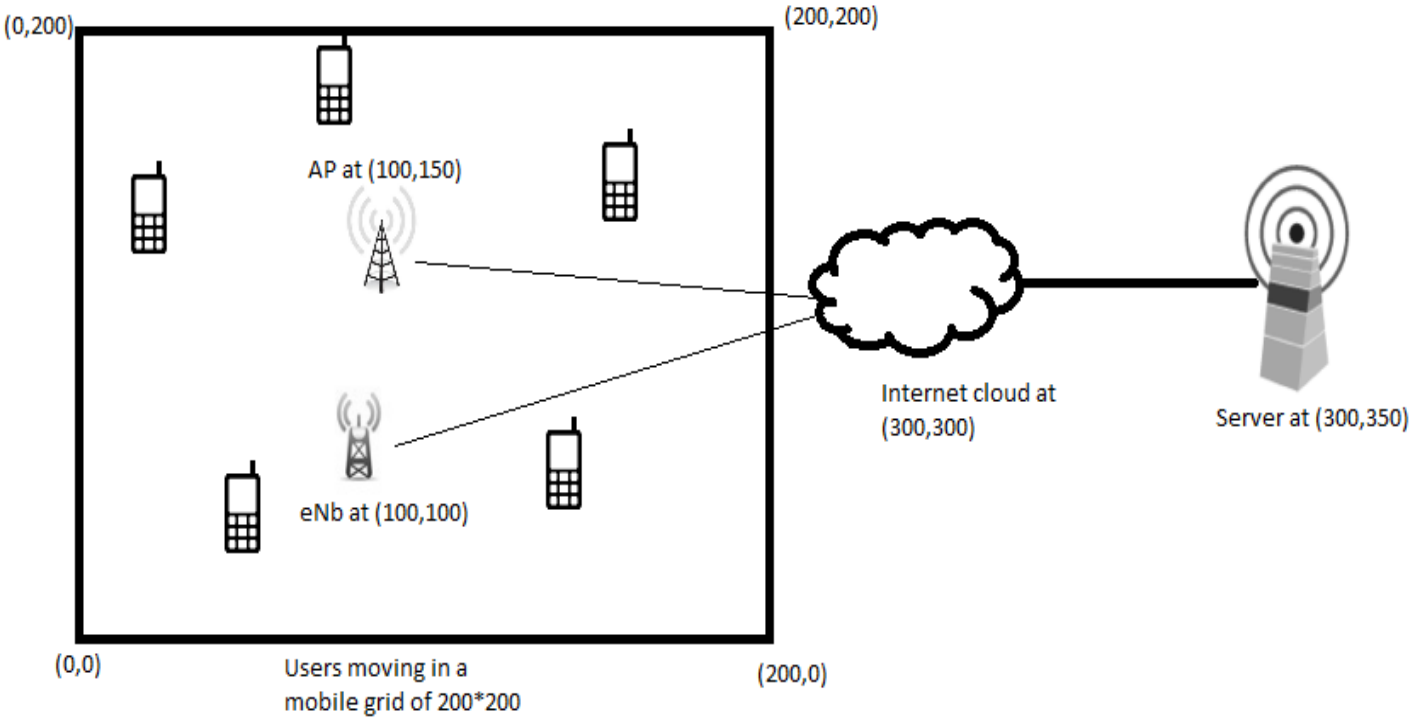
Performance Metrics

- Aggregate Throughput
- End-to-End Delay
- Fairness

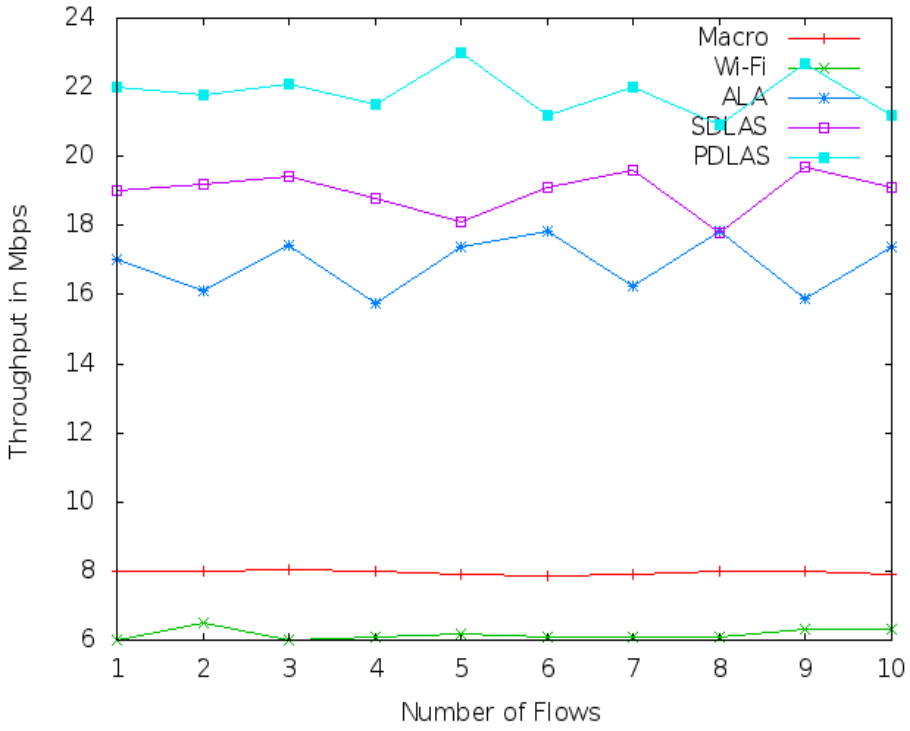
Simulation Parameters

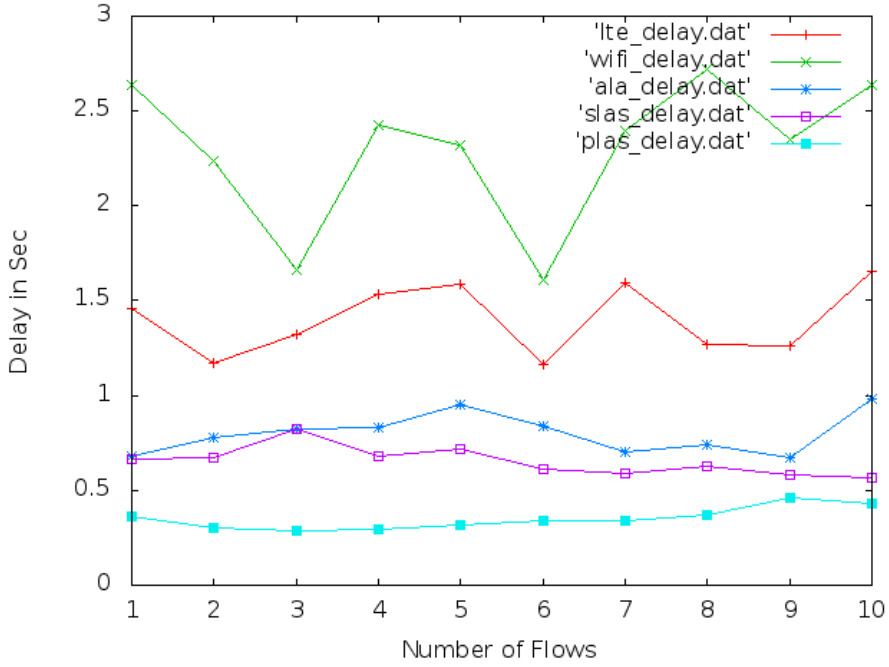
Parameters	Values
Simulator	NS-3
Number of Seeds	10
Number of flows	[1 to 10]
Number of UEs	[1 to 10]
TCP File Size	1 MB
TCP MSS	512B
Mobility Model	Building
Speed of UEs	1 m/s to 3m/s
Number of WI-FI Aps, Macro BSs, Femto BSs	5 , 1 , 5

Simulation Scenario



Performance Analysis of DLAS vs other ALA schemes in LTE-Wi-Fi HetNet



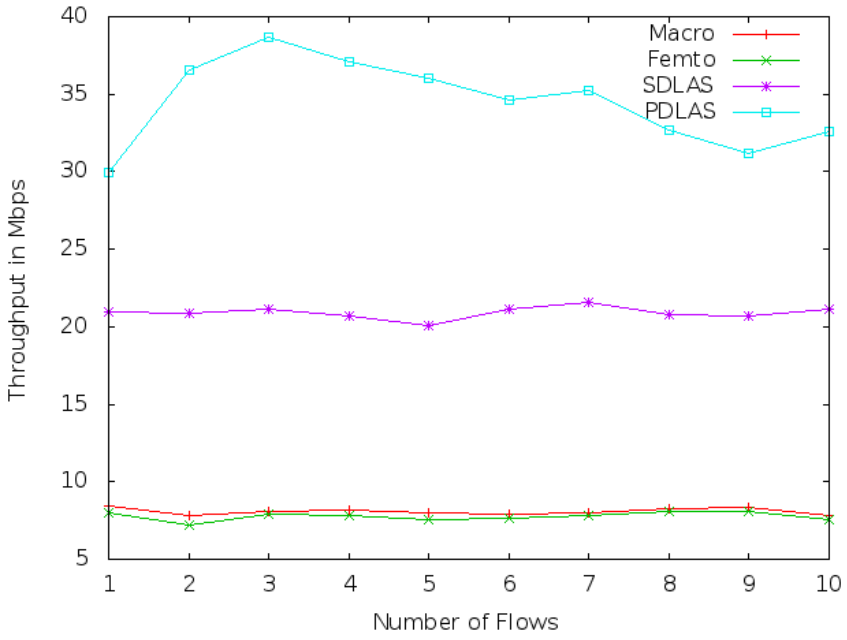


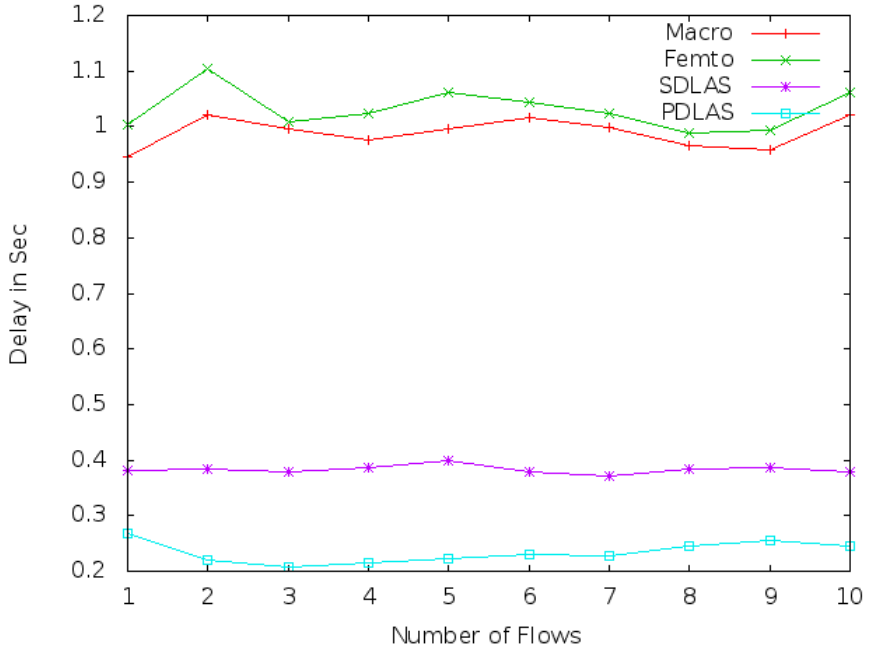
- There is a 9 - 10% increase in aggregate throughput with the SDLAS algorithm when compared to ALA algorithm.

- There is 65% increase in aggregate throughput with the PDLAS algorithm over ALA algorithm.

Performance Analysis of DLAS vs other ALA schemes in LTE-Femto HetNet w/o Mobility

IIT Hyderabad

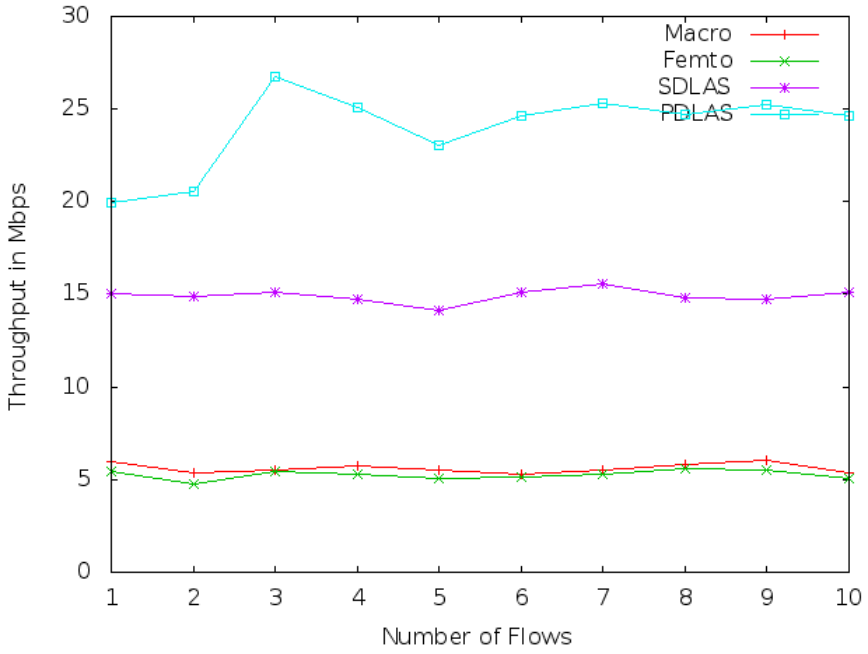


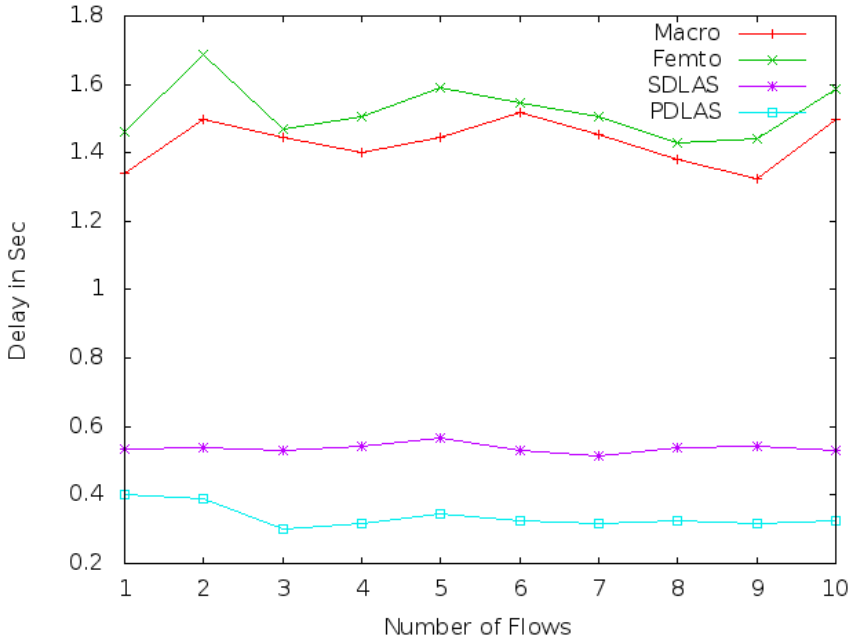


- The percentage of increase in throughput of PDLAS when compared to SDLAS is 65% without mobility.

Performance Analysis of DLAS vs other ALA schemes in LTE-Femto HetNet with Mobility

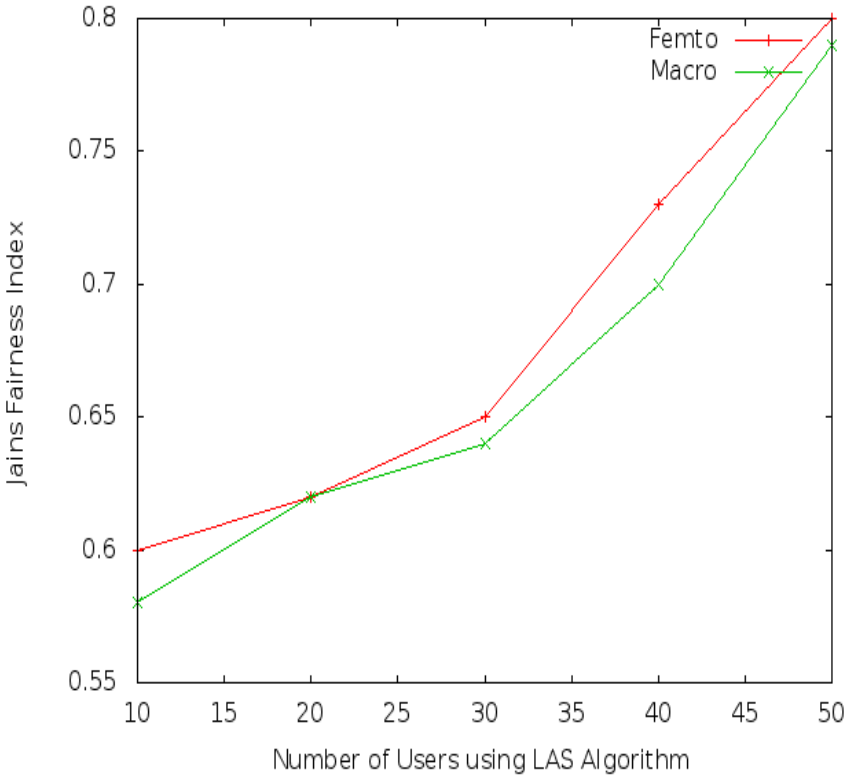
IIT Hyderabad

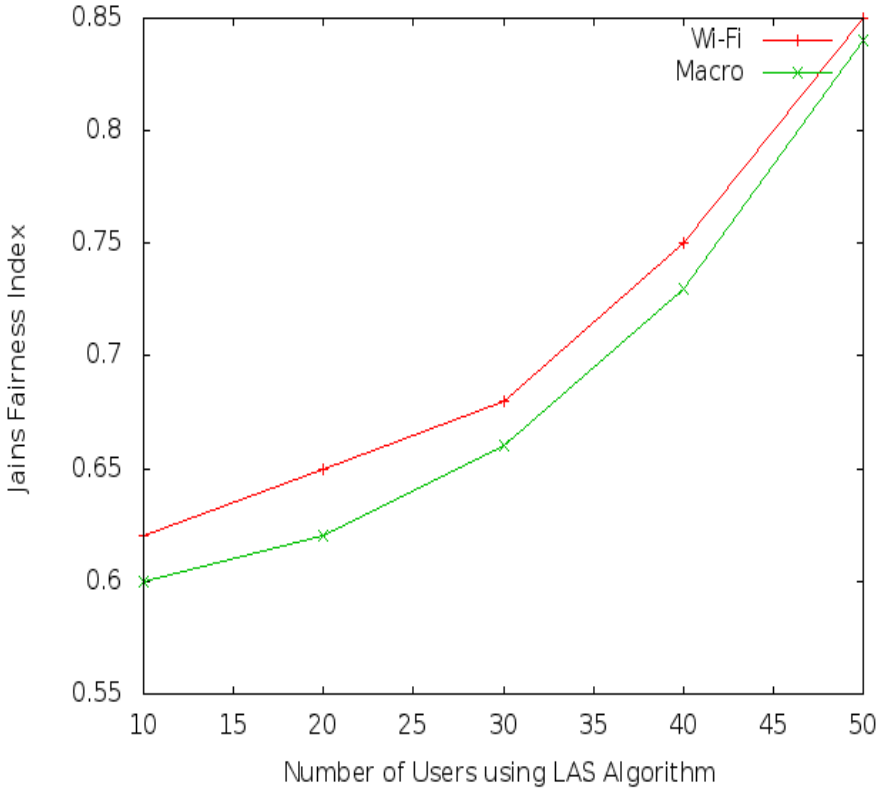




- The percentage of increase in throughput of PDLAS when compared to SDLAS is 60% with mobility.

Fairness of DLAS Scheme





- In this scenario percentage of users not following LAS algorithm(PDLAS) are varied from 10 percent to 50 percent.

- Its observed that though the number of flows increase, fairness index does not dip much, which indicates that the DLAS algorithms are fairer to other TCP users in the network.

Conclusions

- Proposed DLAS algorithms considerably improved achievable throughput by using multiple interfaces of HetNets.
- In accordance to available link capacity of the individual links, data is transferred over singular flows or Multiple parallel flows.
- Incurs lower end-to-end delay and fair to legacy flows in the network.

Future Work

- To measure the performance of DLAS algorithm in heterogeneous handoff scenarios.

- Optimally vary the value of α which enhances the DLAS algorithm performance.

Acknowledgments

- This work was funded by the Deity, Govt. of India (Grant No. 13(6)/2010CC&BT)
- IIT Hyderabad

References

- K. Chebrolu and R. R. Rao, “Bandwidth aggregation for real-time applications in heterogeneous wireless networks,” Mobile Computing, IEEE Transactions on, vol. 5, no. 4, pp. 388–403, 2006.
- R. Rodrigues and P. Druschel, “Peer-to-peer systems,” Commun. ACM, vol. 53, pp. 72–82, Oct. 2010.
- M. Guijarro and R. Gaspar, “Experience and lessons learnt from running high availability databases on network attached storage,” Journal of Physics: Conference Series, vol. 119, no. 4, p. 042015, 2008.

IIT Hyderabad

THANK YOU!

Feedback ?

bala@iith.ac.in

madhurigirinadh@gmail.com