Departure talk

Gustavo B. Figueiredo 01/15/16

Planning and Dimensioning in H-CRAN

References

- **Heterogeneous Cloud Radio Access Networks: A New Perspective For Enhancing Spectral And Energy Efficiencies**. Mugen Peng, Yuan LI, Jiamo JIANG, Jian LI and Chonggang Wang. IEEE Wireless Communications, December 2014.

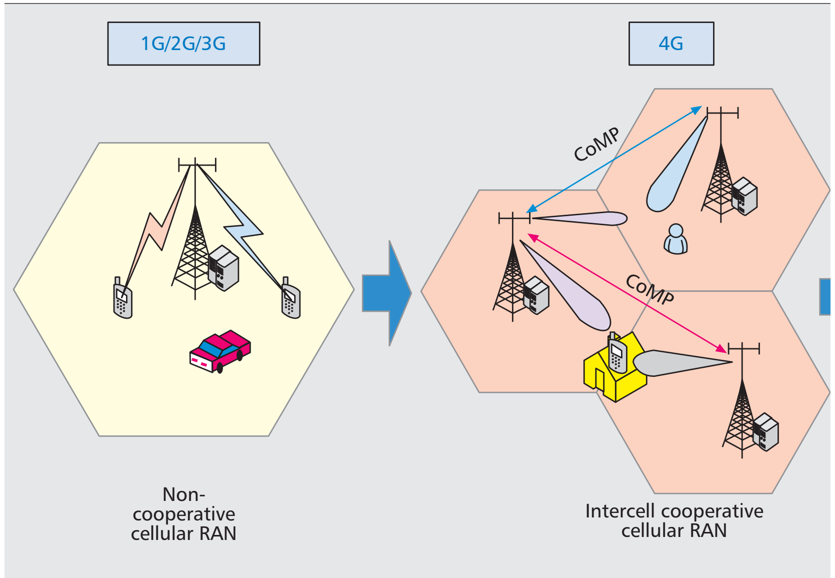
- **Balancing Backhaul Load In Heterogeneous Cloud Radio Access Networks**. Chen Ran, Shaowei Wang, and Chonggang Wang. IEEE Wireless Communications, June 2015.

Motivations

- (ADSL)-like user experience will be provided in the fifth generation (5G) wireless systems
  - average area capacity of 25 Gb/s/km2
  - 100 times higher than current fourth generation (4G) systems
  - a 1000× improvement in energy efficiency (EE) is anticipated by 2020
- Cell densification, is a necessary step to reach such improvements
  - HetNet (Small, pico and femto cells): use of low-power node (LPN).

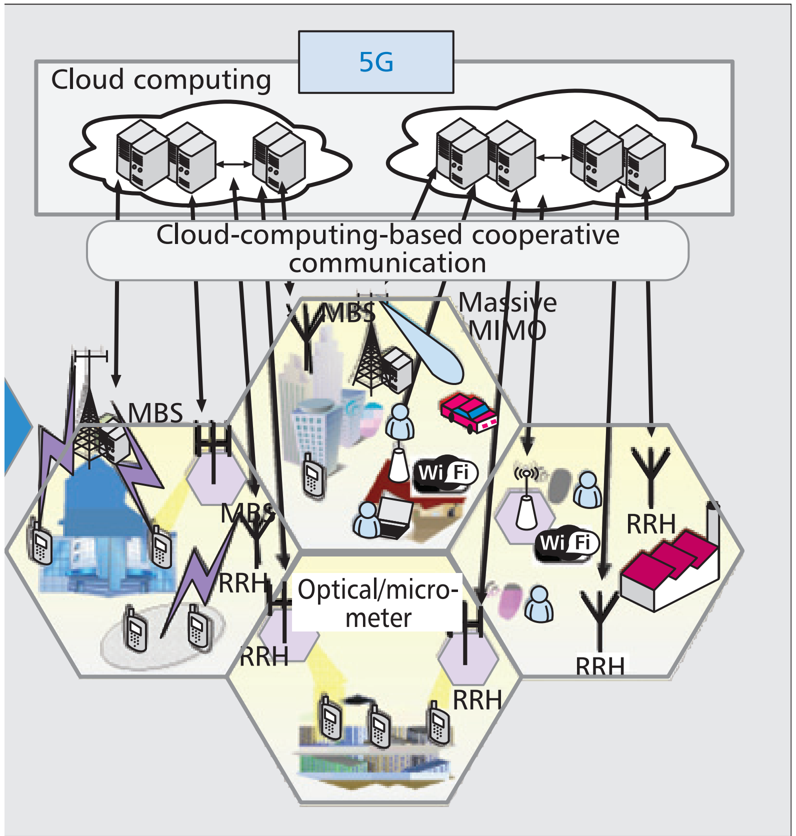
Motivations (problems…)

- Too dense LPNs incur severe interference, which restricts performance gains and commercial development of HetNets.
  - CoMP transmission and reception is the most promising techniques in 4G but it has disadvantages in real networks
  - performance gain depends heavily on the backhaul constraints and even degrades with increasing density of LPNs
- Traditional C-RAN deployments impose extremely high demands on backhauls…
- …and at the current development stage of most operators, it will require high investments to be deployed.

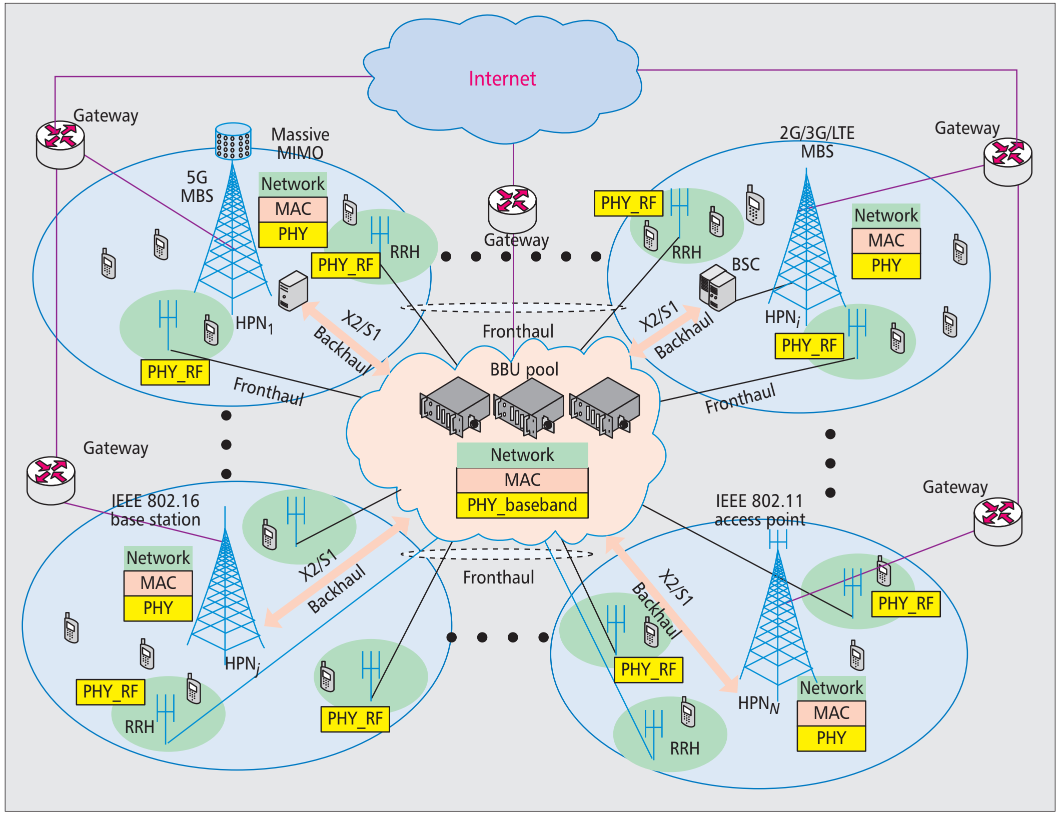


H-CRAN

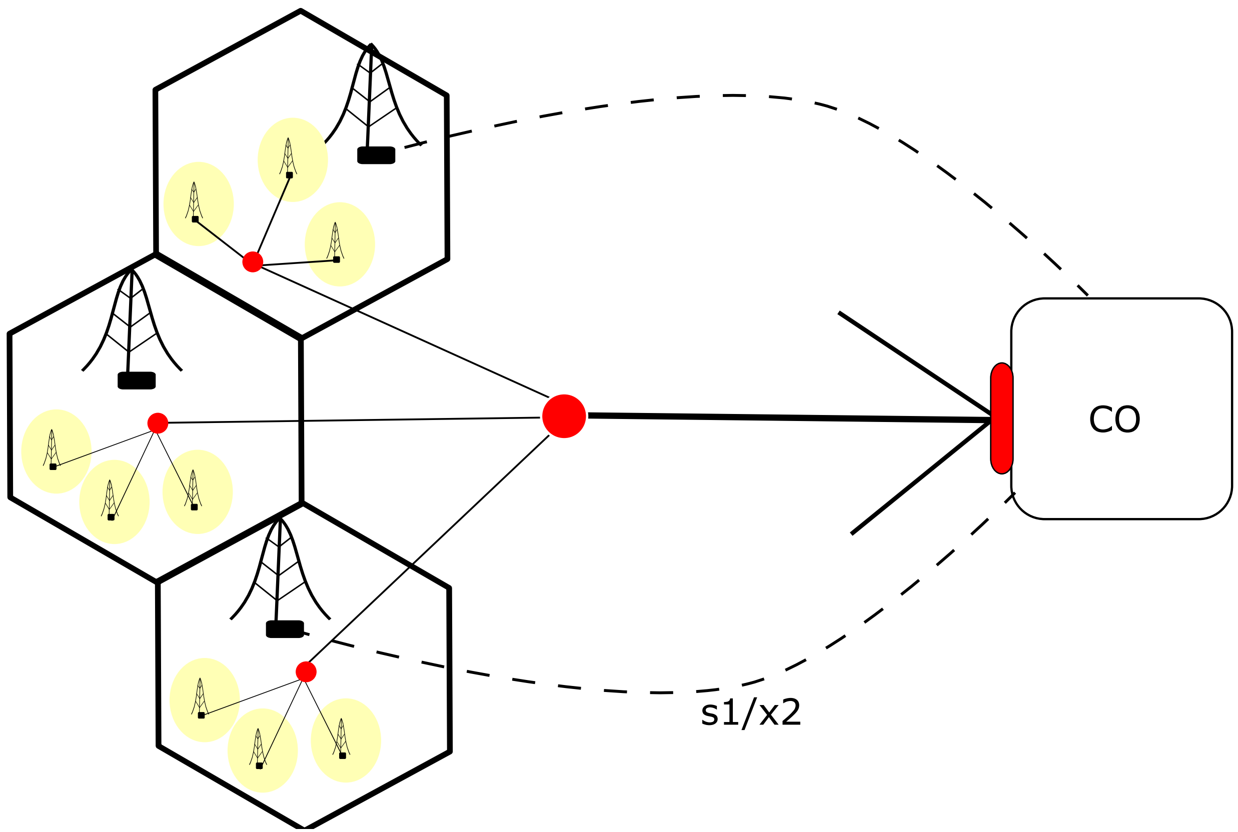
- Combine LPNs with a high-power node (HPN, e.g., macro or micro base station) to form a HetNet.
- Integrate with a C-RAN architecture by connecting the HPN to the BBU pool
- Distribute operations by the C-RAN and the HPN
  - HPN supports voice and low-rate data
  - C-RAN supports high-rate data



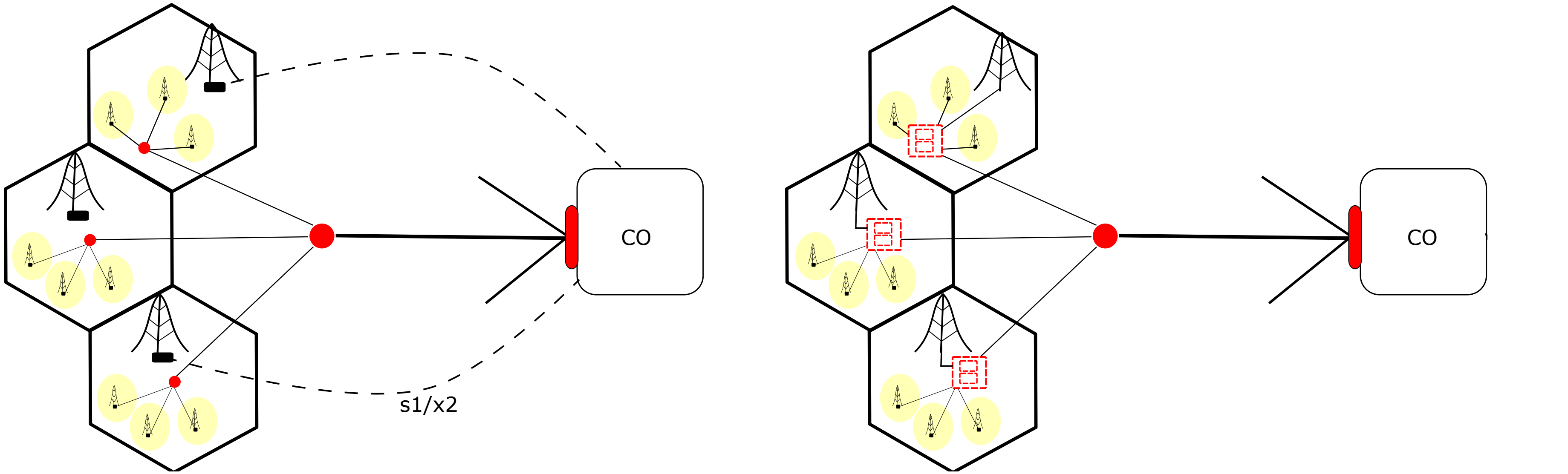
H-CRAN architecture



Conventional H-CRAN



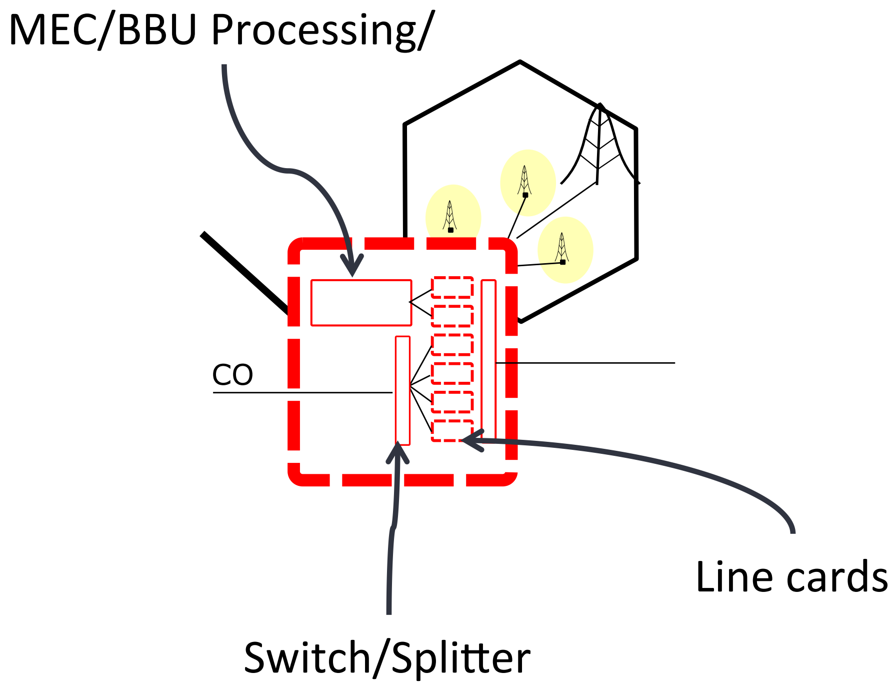
Proposed approach



- Local processing units
- Trade-off between energy consumption and fronthaul/backhaul load

Proposed approach (detailed view)

- Interconnection architecture and technologies



Research opportunities: static scenario

Planning

- Given: Wireless network load
- Determine:
  - Placement of processing functions
  - Level of splitting
  - Control operation (BBU processing, CoMP, etc)

Dimensioning

- Given: network load and topology
- Determine:
  - The number of wavelengths to local processing functions
  - The number of wavelengths to fronthauling

Research opportunities: dynamic scenario

Planning

- Load Balancing strategies for Dynamic Access topologies
  - Enable/Disable local processing units according to wireless traffic fluctuations
  - Consider EE to switch on/off RRH or HPC.
  - Re-optimize parameters for the new topology

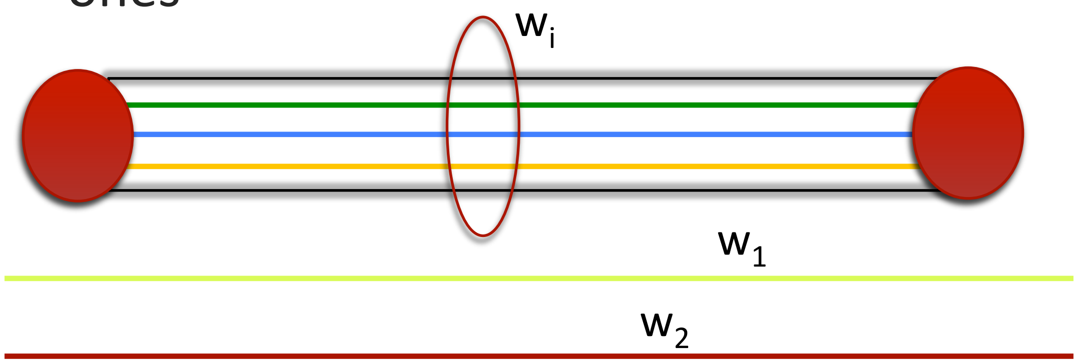
Dimensioning

- Re-size the amount of resources (wavelengths) available to each function
  - Processing
  - Fronthauling

QoS-aware service degradation in EON

Motivations

- In the occurrence of resource shortage, services should be degraded by either:
  - Change the modulation format
    - Decrease transmission rate
    - Increase delay
  - Preempt existing connections to accommodate new ones

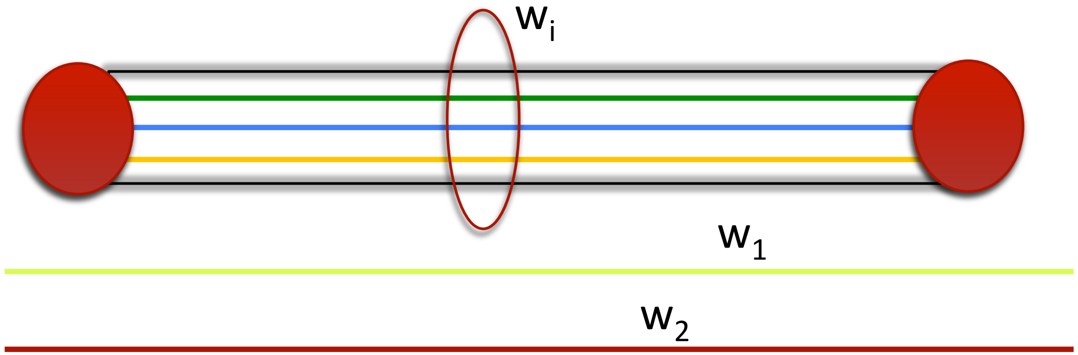


References

- On QoS-Assured Degraded Provisioning in Service Differentiated Optical Telecom Networks. Zhizhen Zhong, Nan Hua, Jipu Li, Gustavo B. Figueiredo, Yanhe Li, Xiaoping Zheng, and Biswanath Mukherjee. Submitted to ICC'16

- On Hybrid IR and AR Service Provisioning in Elastic Optical Networks. Wei Lu, Zuqing Zhu, and Biswanath Mukherjee. Journal Of Lightwave Technology, November 2015.

QoS model vs. state of the network



Weights assigned to lightpaths might be tightened to a QoS model, which in its turn determines the precedence relation among lightpaths

QoS model vs. state of the network

- For practical purposes not only the QoS model should be considered but also the state of the network
- However, considering the state of the network to make decisions would lead to violation of the QoS model..

Proposed solution: to provide a dynamic weighting function to prioritize requests depending on the QoS model and on the state of the network.

Proportional QoS model

- In a proportional service differentiation model it is expected that:

(1) $$\frac{q_i}{s_i} = \frac{q_j}{s_j} \quad (i, j = 1, \ldots, N)$$

where q_i is is the evaluated QoS metric and s_i the differentiation factor for class i and N the total number of classes

let τ be a short interval, the measured QoS metrics obtained during τ is given by:

(2) $$\frac{q_i(t, t+\tau)}{s_i} = \frac{q_j(t, t+\tau)}{s_j} \pm \Delta_{ij}$$

Dynamic weighting function

From equation 1 we have

$$\frac{a_1 q_1}{a_1 s_1} = \ldots = \frac{a_n q_n}{a_n s_n} = \frac{a_1 q_1 + a_2 q_2 + \ldots + a_n q_n}{a_1 s_1 + a_2 s_2 + \ldots + a_n s_n}$$

Or in another words:

$$q_i^* = s_i \frac{\sum_{k=1}^{N} a_k q_k}{\sum_{k=1}^{N} a_k s_k} = \frac{s_i}{\sum_{k=1}^{N} \frac{a_k}{a_T} s_k} \frac{\sum_{k=1}^{N} a_k q_k}{a_T} = \frac{s_i}{s_{wt}} q_T$$

where q_T and s_{wt} represent the total blocking probability and the sum of weighted differentiation parameters and are given by:

$$q_T = \frac{\sum_{k=1}^{N} a_k q_k}{a_T}, s_{wt} = \sum \frac{a_k}{a_T} s_k$$

Dynamic weighting function

- The following equation can be used to measure the deviation of q_i regarding q^*_i

$$\Delta_i = \frac{q_i}{q_i^*}$$

- The following dynamic weighting function can be applied to prioritize requests according to the previous deviation

$$w_i = \alpha(\Delta_i \frac{p_i}{N_i}) + \beta s(t)$$

- Where P_i represents the static priority of each class, N_{i} is the number of class "I" requests and s(t) is a compound function representing the state of the network (fragmentation, lightpath completion time, signaling cost..etc)

Individual Activities

- Problem: Scheduling VPONs to support CoMP
- Design and implementation of simulator
- Analysis of 2^K factorial experimental design
- ICC paper: Load Balancing and Latency Reduction in Multi-User CoMP over TWDM-VPONs
- Extension to journal: New metrics, load-aware scheduling algorithm

Collaborations

	Task	Fellow
1	Bayesian Network and Dynamic Bayesian Network models for capturing cascading failures	Carlos
2	Analytical Model based on Generalized Processor Sharing to estimate maximum achievable delay in degraded service networks	Zhizhen
3	Scheduling algorithm for VPON formation to support SU-CoMP	Zhizhen
4	BBU placement in Optical Data centers to support multi-tenant systems	Carlos
5	A fuzzy optimization model to the traveling repairman,	Chen Ma
6	Optimality proofs for scheduling algorithms in NG-EPON	Lin
7	CoMP-set Selection and VPON scheduling for MU-COMP	Xinbo
8	Resource allocation strategies in application-aware networks	Divya

Learnings

- “Be a leader“
- “Be problem-oriented rather than solution oriented”
- “Everything can be researchable but we're only interested in problems that can be fundable”
- “We're not interested in problems that were studied by others”

Bis

- “High-quality results and presentation is the minimum expected”

Massimo

Goals

- Improve English
- Make friends
- Collect cultural experiences

Personal Goals

- Improve English
- **Make friends**
- **Collect cultural experiences**

Thank you