Cross-Layer Resource Allocation With Elastic Service Scaling in Cloud Radio Access Network

Md.Al-Helal Jobayed Ullah Roll:SH-51 Roll:EK-107

Computer Science & Engineering CSEDU

February 25, 2018





Cross-Layer Resource Allocation With Elastic Service Scaling in Cloud Radio Access Network

Jianhua Tang Wee Pen Tay Tony Q. S. Quek

IEEE Transactions on Wireless Communications, vol 14, no. 9

September 2015





Assumption

Assumption

$$\mu_i, c_i > \lambda_i$$

$$\varphi_i(\mu_i) \ge 0, \forall \mu_i$$

 $\varphi_i(\mu_i)$ is a convex and increasing function of μ_i

- \bullet μ_i service rate
- ullet c_i transmission rate
- λ_i arrival rate
- $\bullet \ \varphi_i(\mu_i) = k_i \mu_i^{a_i}$
- $k_i > 0$ and $a_i > 1$ are positive constants.





Aim

Minimizing system power consumtion in C-RAN, which consists of three components:

- Power consumption in BBU pool
- Power consumption in fiber links
- Power consumption in RRHs





Delay

$$d_i = \frac{1}{\mu_i - \lambda_i} + \frac{1}{c_i - \lambda_i}$$

where,

- \bullet d_i total delay
- μ_i service rate
- λ_i arival rate





Recieved signal at UE i

$$\hat{x_i} = \sum_{j \in \mathcal{A}} h_{ij}^H w_{ij} x_i + \sum_{k \neq i}^N \sum_{j \in \mathcal{A}} h_{ij}^H w_{kj} x_k + \delta_i$$

where,

ullet set of active RRHs

• x_i data symbol for ith user

 $\bullet \ w_{ij} \in \mathbb{C}^k \qquad \qquad \text{transmit beamformer for UE } i \text{ from RRH } j$

 $\bullet \ h_{ij}^H \in \mathbb{C}^k \qquad \qquad \text{channel from RRH } j \text{ to UE } i$

• $\delta_i \sim \mathcal{CN}(0, \sigma_i)$ additive white Gaussian noise(AWGN) at UE i

• $i \in \mathcal{N}$





Signal-to-Interference-plus-Noise-Ratio(SINR) at UE i

$$\mathsf{SINR}_i(\mathcal{A}) = \frac{\left|\sum\limits_{j \in \mathcal{A}} h_{ij}^H w_{ij}\right|^2}{\sigma_i^2 + \sum\limits_{k \neq i}^N \left|\sum\limits_{j \in \mathcal{A}} h_{ij}^H w_{kj}\right|}$$

where,

 \circ σ_i

noise

A

set of active RRHs

• $w_{ij} \in \mathbb{C}^k$

transmit beamformer for UE i from RRH j

 $\bullet \ h_{ij}^H \in \mathbb{C}^k$

channel from RRH j to UE i

• $i \in \mathcal{N}$







The achieveable rate c_i of UE i should satisfy

$$c_i \le B_i \log(1 + \mathsf{SINR}_i(\mathcal{A}))$$

where,

• B_i bandwidth for UE i

• SINR Signal-to-Interference-plus-Noise-Ratio

ullet set of active RRHs





Transmitting Power

Each RRH j has maximum transmitting power constraint

$$\sum_{i=1}^{N} w_{ij}^{H} w_{ij} = \sum_{i=1}^{N} ||w_{ij}||^{2} \le E_{j}$$

where,

- $w_{ij} \in \mathbb{C}^k$ transmit beamformer for UE i from RRH j
- $i \in \mathcal{N}$
- $j \in \mathcal{L}$





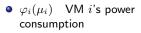
Problem Formulation

$$\min_{\mu_{i}, c_{i}, w_{ij}, \mathcal{A}} \sum_{i}^{N} \varphi_{i}(\mu_{i}) + |\mathcal{A}| P_{f} + \frac{1}{\eta} \sum_{i=1}^{N} \sum_{j \in \mathcal{A}} w_{ij}^{H} w_{ij}$$

subject to

$$\frac{1}{\mu_i - \lambda_i} + \frac{1}{c_i - \lambda_i} \le \tau_i$$
$$\lambda_i < \mu_i, \lambda_i < c_i$$
$$c_i \le B_i \log(1 + \mathsf{SINR}_i(\mathcal{A}))$$

$$\sum_{i=1}^{N} w_{ij}^{H} w_{ij} \leq E_{i}, \quad \forall i \in \mathcal{N}, \quad \forall j \in \mathcal{L}$$



- ullet μ_i VM i's service rate
- ullet P_f power consumption of active fibre links
- $\begin{array}{ll} \bullet & \eta \in (0,1) & \text{ineffficiency} \\ \text{coefficient of amplifier in} \\ \text{RRH} \end{array}$
- ullet ${\cal A}$ set of active RRHs
- $\begin{array}{ll} \bullet & w_{ij} \in \mathbb{C}^k & \text{transmit} \\ \text{beamformer for UE } i \text{ from} \\ \text{RRH } j \end{array}$
- \bullet $i \in \mathcal{N}$
- $j \in \mathcal{A}$







QWSRM

Quasi Weighted Sum-Rate Maximization Problem





Quasi Weighted Sum-Rate Maximization Problem

QWSRM

$$\min_{c_i, w_{ij}} \sum_{i=1}^{N} -\varepsilon_i c_i$$

subject to,

$$c_i \le B_i \log(1 + \mathsf{SINR}_i(\mathcal{A})), \quad \forall i \in \mathcal{N}$$

$$\sum_{i=1}^{N} w_{ij}^{H} w_{ij} \le E_i, \quad \forall j \in \mathcal{A}$$

 \bullet ε_i

arbitrary nonnegative weight

 c_i B_i

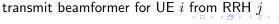
transmission rate bandwidth for UF *i*

• A

set of active RRHs

 \bullet E

- maximum power on a link
- lacksquare $w_{ij} \in \mathbb{C}^k$





Generalization of WSRM

$$\min_{c_i, w_{ij}} f(\mathbf{c})$$

subject to,

$$\sum_{i=1}^{N} w_{ij}^{H} w_{ij} \le E_i, \quad \forall j \in \mathcal{A}$$

Where the objective function $f(\mathbf{c})$, for $0 \le \mathbf{c} \le \bar{\mathbf{c}}$ has the following properties:

transmission rate

- $f(\mathbf{c})$
- $f(\mathbf{c}) < \infty$
- $f(\mathbf{c})$
- $w_{ij} \in \mathbb{C}^k$
- lacksquare c_i
- \bullet E_j
- lacktriangledown lacktriangledown
 - $\mathbf{c} = [c_1, \dots, c_N]^T$

is a function only of ${\bf c}$, and is continuously differentiable, and is convex in the feasible region transmit beamformer for UE i from RRH j

maximum power on a link set of active RRHs



$$\gamma_{ub}(\mathcal{Q}) = \begin{cases}
f(\mathbf{c}_{min}), & \mathbf{c}_{min} \in \mathcal{F} \\
+\infty, & otherwise
\end{cases}$$

$$\gamma_{lb}(\mathcal{Q}) = \begin{cases}
f(\mathbf{c}_{max}), & \mathbf{c}_{max} \in \mathcal{F} \\
+\infty, & otherwise
\end{cases}$$

where,

$$\bullet \mathbf{c}_{min} = \left[c_{1,min}, \dots, c_{N,min}\right]^{T}$$

$$\bullet \mathbf{c}_{max} = \left[c_{1,max}, \dots, c_{N,max}\right]^T$$

- \bullet $\gamma_{ub}(\mathcal{Q})$ upper bound
- ullet $\gamma_{lb}(\mathcal{Q})$ lower bound





BnB algorithm for QWSRM problem

```
Input: Q_{init}, A, and \{(c).
Initialize: Obtain c_i by solving \frac{\delta f(c)}{\delta c_i} = 0, for i \in \mathcal{N}. Set k = 1, \mathcal{B} = \mathcal{Q}_{init}, u_1 = 0
   \gamma_{ub}(\mathcal{Q}_{init}) and l_1 = \gamma_{lb}(\mathcal{Q}_{init}).
   Check the feasibility of problem (17) with given
   if feasible then
         c_0 = \tilde{c};
   else
         while u_k - l_k > \epsilon do
               Branching:
                   • Set Q_k = Q, where Q satisfies \gamma_{lb}(Q) = l_k.
                   • Split Q into Q_I and Q_{II}, along one of its longest edges.
                   • Update \mathcal{B}_{k+1} = (\mathcal{B}_k \setminus \{\mathcal{Q}_k\}) \bigcup (\mathcal{Q}_{\mathrm{I}}, \mathcal{Q}_{\mathrm{II}}).
```

Bounding:

- Update $u_{k+1} = \min_{\mathcal{Q} \in \mathcal{B}_{k+1}} \{ \gamma_{ub}(\mathcal{Q}) \}$
- Update $l_{k+1} = \min_{\mathcal{Q} \in \mathcal{B}_{k+1}} \{ \gamma_{lb}(\mathcal{Q}) \}$

end while

Set
$$c_0 = c_{min}$$
; end if

Output: c_0 .

Thank You



