# Application aware converged access network

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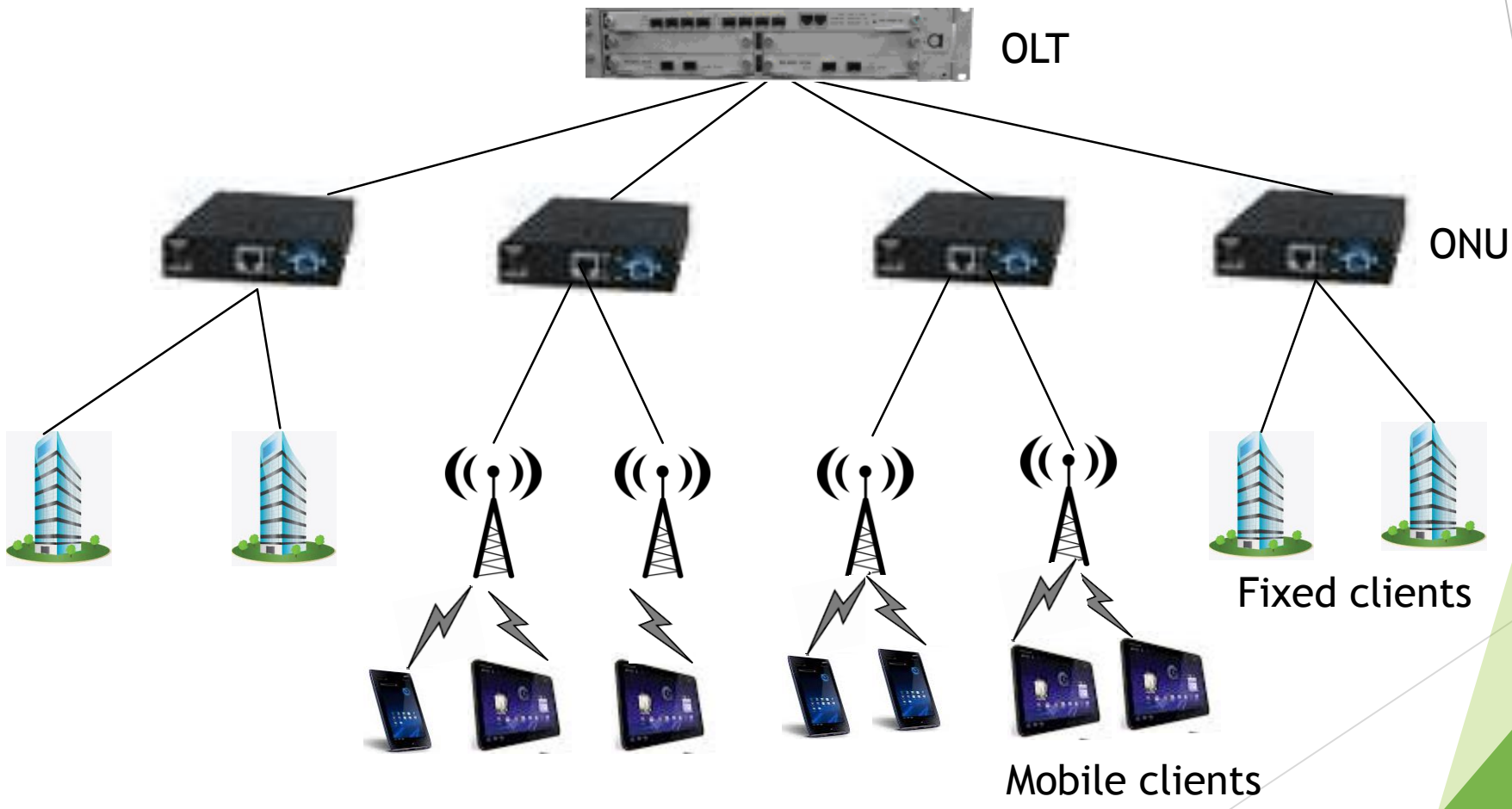
# Architecture



# Description about architecture

- PON architecture supports both fixed users and small cells
- NGFI is striving for traffic dependent, packet based fronthaul
- PON can be used as fronthaul for next general packet based fronthaul
- There is need for intelligent resource allocation that takes into account various client needs
- This study focuses on QoE aware resource allocation in LTE (wireless) and also fronthaul bandwidth provisioning based on client demands
- Applications considered are video streaming, video conference since they take up major access resources.

China Mobile view on Next Generation Fronthaul Interface http://www.ieee1904.org/email/pdfLV66u9TRJ8.pdf

# Two level bandwidth dimensioning

- Resources are allocated in wireless domain using application information to maximize the QoE of users
- There algorithms are considered to achieve this
- Skype/Youtube based adaptive streaming is incorporated
- Each profile is made of certain resolution and frames per second
- Each profile is associated with an empirical MoS
- This information is made available at the MAC scheduler (could be centralized or independent) to allocate resources such that overall QoE is improved
- Once the wireless resources are allocated, fronthaul can be dimensioned for traffic/QoE demand

# Supporting fronthaul standards

- **Interface II** between QAM+Multi-antenna mapping and Resource mapping by NGMI, can be packetized and traffic dependent
- Next generation frontahaul interface by china mobile is proposed to be Ethernet based
- IEEE workgroup 1903.4 is working on radio over Ethernet
- The proposed scenario also works for full fledged eNodeBs which backhaul the traffic to core network

Next Generation Mobile Networks 5G white paper https://www.ngmn.org/5g-white-paper.html
IEEE workgroup 1904.3 on Radio over Ethernet

# Skype profile levels

- Skype uses video adaptation based on network state
- Supported resolutions: 19200, 76800, 307200
- Supported frame rates: 5 to 28 fps
- Required data rates: 320 kbps to 27.6 mbps
- MoS is calculated using empirical formula using above parameters
- MoS ranges from 2.9 to 4.7
- Mobile and fixed clients using adaptive streaming applications are classified into 3 types based on minimum acceptable MoS

# Resource allocation problem

- Given UE and cell association, client type and channel condition for each UE, find out the resource allocation such that it maximizes overall QoE of the system
- Constraints: total resource blocks, minimum acceptable MoS for each client type
- Objective: Cumulative MoS
- System: LTE 20 MHz,  Rayleigh fading channel

# Fading channel TBS assignment

| -1 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 2536 | 2536 | 2600 | 2600 | 2664 | 2664 | 2728 | 2728 | 2728 | 2792 |
| 1 | 3368 | 3368 | 3368 | 3496 | 3496 | 3496 | 3496 | 3624 | 3624 | 3624 |
| 2 | 4136 | 4136 | 4136 | 4264 | 4264 | 4264 | 4392 | 4392 | 4392 | 4584 |
| 3 | 5352 | 5352 | 5352 | 5544 | 5544 | 5544 | 5736 | 5736 | 5736 | 5736 |
| 4 | 6456 | 6456 | 6712 | 6712 | 6712 | 6968 | 6968 | 6968 | 6968 | 7224 |
| 5 | 7992 | 7992 | 8248 | 8248 | 8248 | 8504 | 8504 | 8760 | 8760 | 8760 |
| 6 | 9528 | 9528 | 9528 | 9912 | 9912 | 9912 | 10296 | 10296 | 10296 | 10296 |
| 7 | 11064 | 11448 | 11448 | 11448 | 11448 | 11832 | 11832 | 11832 | 12216 | 12216 |
| 8 | 12576 | 12960 | 12960 | 12960 | 13536 | 13536 | 13536 | 13536 | 14112 | 14112 |
| 9 | 14112 | 14688 | 14688 | 14688 | 15264 | 15264 | 15264 | 15264 | 15840 | 15840 |
| 10 | 15840 | 16416 | 16416 | 16416 | 16992 | 16992 | 16992 | 16992 | 17568 | 17568 |
| 11 | 18336 | 18336 | 19080 | 19080 | 19080 | 19080 | 19848 | 19848 | 19848 | 19848 |
| 12 | 20616 | 21384 | 21384 | 21384 | 21384 | 22152 | 22152 | 22152 | 22920 | 22920 |
| 13 | 23688 | 23688 | 23688 | 24496 | 24496 | 24496 | 25456 | 25456 | 25456 | 25456 |
| 14 | 26416 | 26416 | 26416 | 27376 | 27376 | 27376 | 28336 | 28336 | 28336 | 28336 |
| 15 | 28336 | 28336 | 28336 | 29296 | 29296 | 29296 | 29296 | 30576 | 30576 | 30576 |
| 16 | 29296 | 30576 | 30576 | 30576 | 30576 | 31704 | 31704 | 31704 | 31704 | 32856 |
| 17 | 32856 | 32856 | 34008 | 34008 | 34008 | 35160 | 35160 | 35160 | 35160 | 36696 |
| 18 | 36696 | 36696 | 36696 | 37888 | 37888 | 37888 | 37888 | 39232 | 39232 | 39232 |
| 19 | 39232 | 39232 | 40576 | 40576 | 40576 | 40576 | 42368 | 42368 | 42368 | 43816 |
| 20 | 42368 | 42368 | 43816 | 43816 | 43816 | 45352 | 45352 | 45352 | 46888 | 46888 |
| 21 | 45352 | 46888 | 46888 | 46888 | 46888 | 48936 | 48936 | 48936 | 48936 | 51024 |
| 22 | 48936 | 48936 | 51024 | 51024 | 51024 | 51024 | 52752 | 52752 | 52752 | 55056 |
| 23 | 52752 | 52752 | 52752 | 55056 | 55056 | 55056 | 55056 | 57336 | 57336 | 57336 |
| 24 | 55056 | 57336 | 57336 | 57336 | 57336 | 59256 | 59256 | 59256 | 61664 | 61664 |
| 25 | 57336 | 59256 | 59256 | 59256 | 61664 | 61664 | 61664 | 61664 | 63776 | 63776 |
| 26 | 66592 | 68808 | 68808 | 68808 | 71112 | 71112 | 71112 | 73712 | 73712 | 75376 |

# MCKP - Dynamic Programming Algorithm

- This problem can be modelled as a multiple choice knapsack problem and dynamic programming approach can be used to perform resource allocation
- For every UE weights and profits are determined based on their client type and channel condition
- Weight is number of resource blocks needed to achieve a certain video rate and hence certain MoS
- Profit is the incremental MoS achieved by using certain profile level
- Steps:
  - For every UE find out channel condition (every TTI), based on which maximum coding rate is calculated
  - Using this coding rate find out the acceptable weights and profits for each UE
  - For every UE pick one profile level (w,p) such that cumulate MoS is maximized

# Modified Round Robin Algorithm

- Allocate resources such that minimum acceptable profiles are supported for all UE
- Calculate allocated budget based on what ever is allocated
- Choose a random UE number
- Allocate best profile within remaining budget that increases MoS of  UE
- Repeat this in a round robin fashion until all the resources are allocated or all UEs are visited

# Water-filling algorithm

- Allocate resources such that minimum acceptable profiles are supported for all UE
- Sort the UEs in decreasing channel conditions (coding rate)
- Calculate allocated budget based on what ever is allocated
- Select the UE with maximum coding rate
- Allocate best profile within remaining budget that increases MoS of  UE
- Repeat this in a descending order of channel rates until all the resources are allocated or all UEs are visited

# Results

- … still working on them …

# Deliverables

- Results for MCKP algorithm
- Results for bandwidth allocation in fronthaul/backhaul part
- Better model/algorithms?