# OPTIMIZING QOE FOR SCALABLE VIDEO MULTICAST OVER WLAN

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# Outline

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  - Scalable video coding
- Introduction to QoE
- Optimizing QoE
  - QoE estimation tool
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- Results
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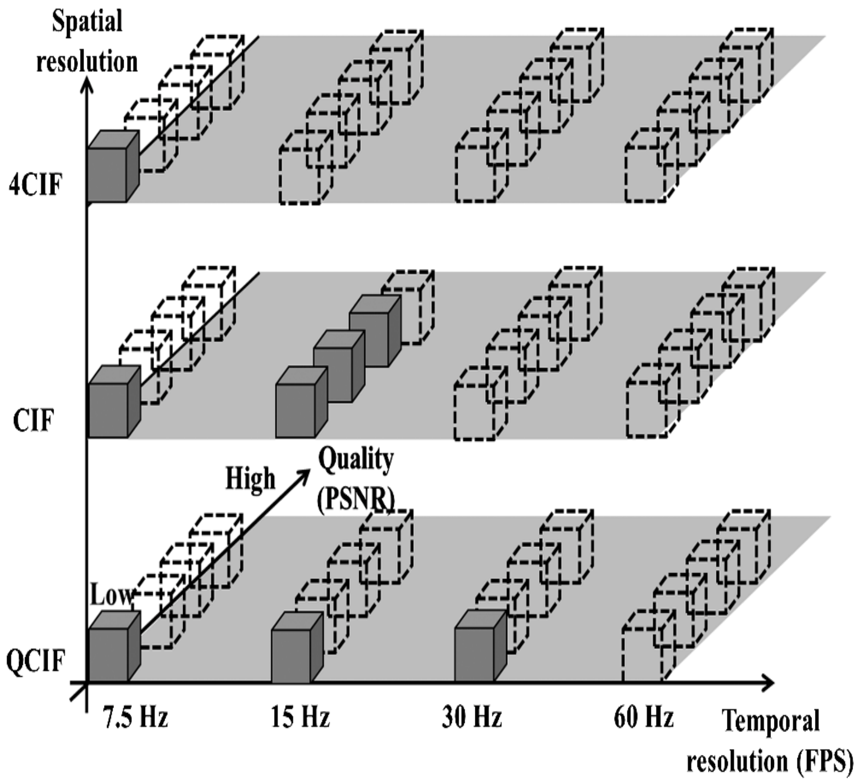
# Background - *Wireless Multicast*

- Multicast in wireless environment
  - group transmission
  - send at basic rate to reach far station
- Pros ☺
  - efficient transmission: send once reach all
  - several applications: conference meeting, mobile commerce, military command and control, distance education, entertainment service
- Cons ☹
  - multicast traffic set to lowest rate ⇨ long channel occupancy
  - lack of ACK and retransmission

➡ Results in the well-known problem of **Rate Adaptation** that changes modulation according to network condition

# Background -*Scalable video coding (SVC)*




- 3 fundamental types of scalabilities
  - spatial resolution (picture resolution),
  - temporal resolution (frame rate),
  - quality (encoding quality)

⇨ Scalability achieved via a layered approach composed of one base layer and several enhancement layers

# Objectives

- Propose a mechanism that uses
  - both layering transmission in SVC and rate adaptation capability in IEEE 802.11 to optimize user experience
  - multiple multicast sessions to better adapt to conditions experienced by different users
  - an optimized modulation for transmission of each layer by Binary Integer Linear Programming
- Many existing works are based on QoS parameters but user experience is final goal so it is more interesting to use a QoE-driven approach

# Introduction to Quality of Experience

- From QoS to QoE
  - QoS (Quality of Service): measurement of technical parameters (throughput, loss, delay, jitter, …)
  - QoE (Quality of Experience): overall acceptability of an application or service, as perceived subjectively by user.

| MOS* | Quality | Impairment |
|---|---|---|
| 5 | Excellent | Imperceptible |
| 4 | Good | Perceptible but not annoying |
| 3 | Fair | Slightly annoying |
| 2 | Poor | Annoying |
| 1 | Bad | Very annoying |

*MOS: Mean Opinion Score

# QoE estimation

- **Subjective approach**: human observers marks the score for multimedia applications
  - ☺ Real evaluation from human
  - ☹ Time-consuming and require manpower
    - ➡ impossible to implement in real-time mechanisms
- **Objective approach**: monitor traffic in terms of technical parameters such as throughput, delay, jitter, loss…
  - ☺ Automatic procedure
  - ☹ Not correlate well with real human evaluation
    - ➡ easy to implement

➡ We need a hybrid approach having advantage of both and avoid their drawbacks

# Pseudo-Subjective Quality Assessment (PSQA)

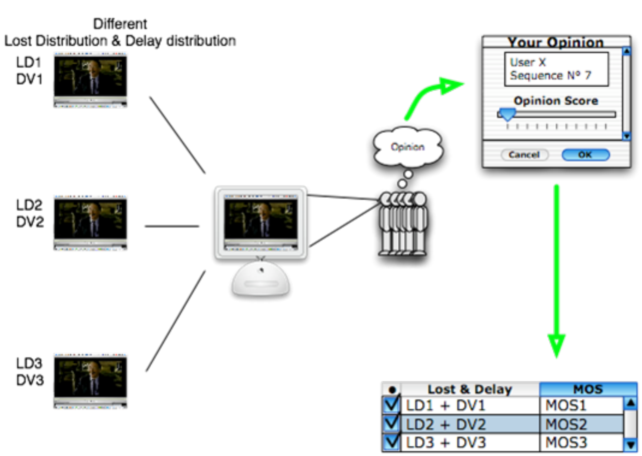
- **Hybrid approach** based on statistic learning using Random Neural Network (RNN)

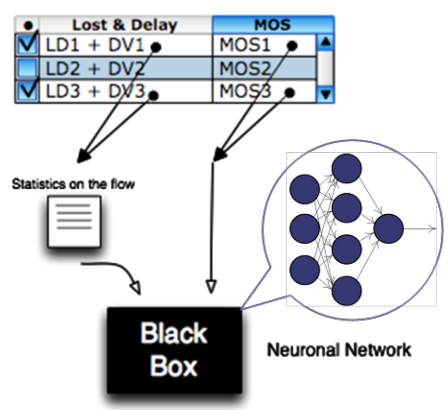
- **Methodology**

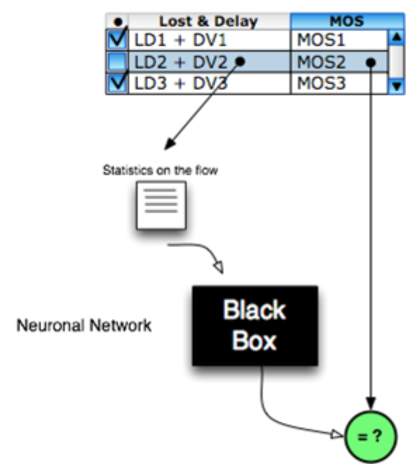
  1- Database generation

  2-Training

  3-Validation



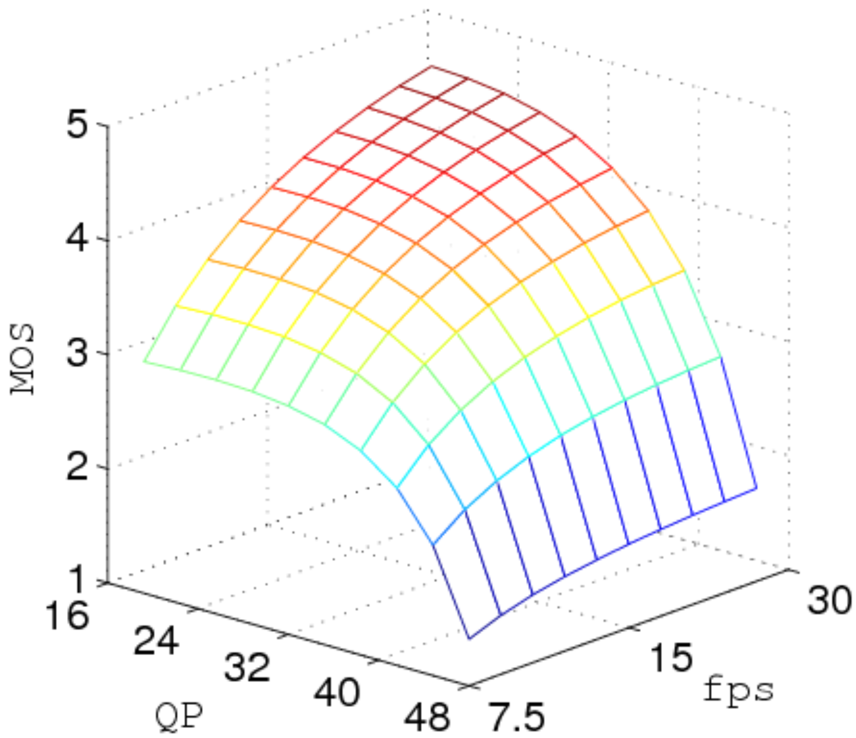




$$Config = \{p_1, p_2, \ldots, p_n\}$$

$$f(p_1, p_2, \ldots, p_n) \rightarrow MOS$$

# QoE function



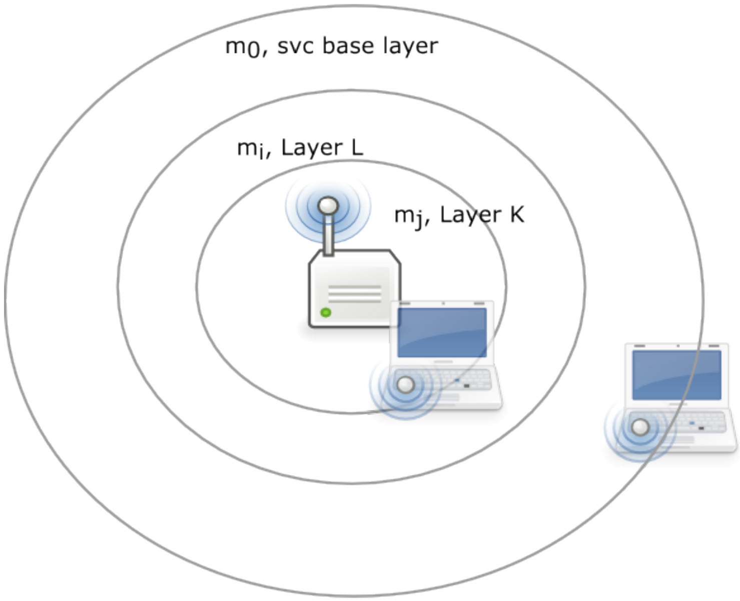

- Methodology :
  - ITU R BT 500-11 and ITU R P.910
  - MOS scale of 1-5
  - 15 users
- QoE Model for SVC Multicast

  QoE = PSQA(QP, fps)
- PSQA is able to capture this non linear function
- Real MOS vs. estimated MOS with Root Mean Square Error 0.36 on the scale of 1 to 5

# QoE-driven SVC Wireless Multicast

- WLAN different receiver modulations (m1, m2, ...) depending on user conditions

  => what is the optimal way to transmit different layers using different modulations?




- Our objectives:

  Maximize QoE and guarantee QoE at least 3 to all users

# Binary Integer Linear Programming

Find an allocation matrix

$$\Lambda = \begin{bmatrix} \lambda_{1,1} & \cdots & \\ & \ddots & \\ \vdots & \lambda_{k,l} & \vdots \\ & \cdots & \lambda_{K,L} \end{bmatrix}$$

$K$: modulations, $L$: Layers

$\lambda_{k,l}$ =1 if layer l is transmitted with modulation $m_k$

$\lambda_{k,l}$ = 0 otherwise

that maximizes sum of QoE of all users

$$Q = \sum_{k=1}^{K} \sum_{l=1}^{L} q_l n_k \sum_{h=1}^{k} \lambda_{l,h}$$

$q_l$: Quality of layer l

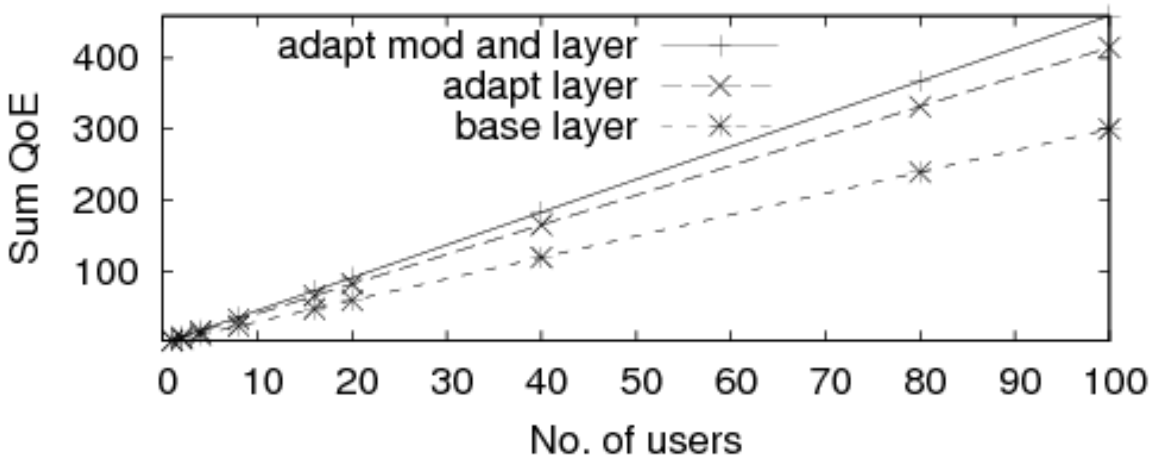
$n_k$: User $n_k$

regarding some constraints.

# Parameters for numerical results

| Variable | Values |
|---|---|
| Bit rate | IEEE 802.11a with *8 available bitrates* 6, 9, 12, 18, 24, 36, 48, 54 Mbps |
| SVC layer | *8 layers* (1 base and 7 enhancement) |
| Distance variation *d* | from uniformly distributed (d=1) to dense near AP (d=0.2), Dmax=37m |
| Resource variation *ρ* | amount of resource slots available for multicast transmission from 100% (1.0) down to 40% (0.4) |

# Results – Sum QoE

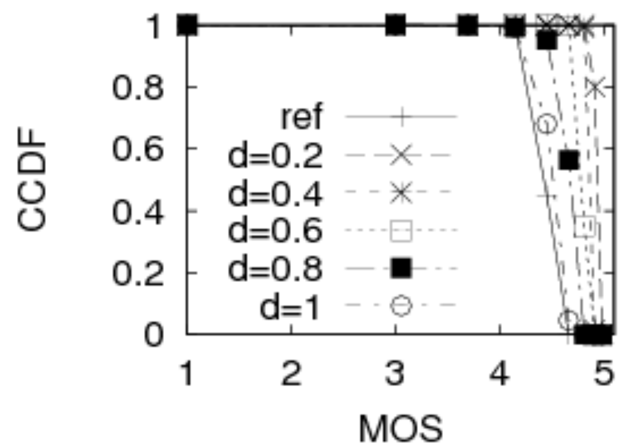



QoE-driven (*adapt mod and layer*) compared to

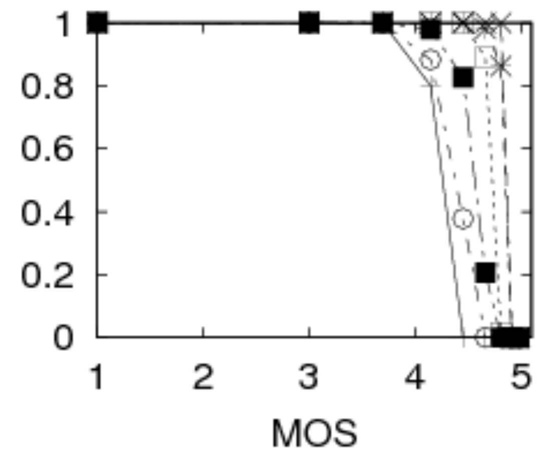
- *Base layer* Basic rate (6Mbps)
- *Adaptive layer only* (MANE varies number of layers according to current network condition) using 6Mbps

(in case of uniformly distributed users in the area)

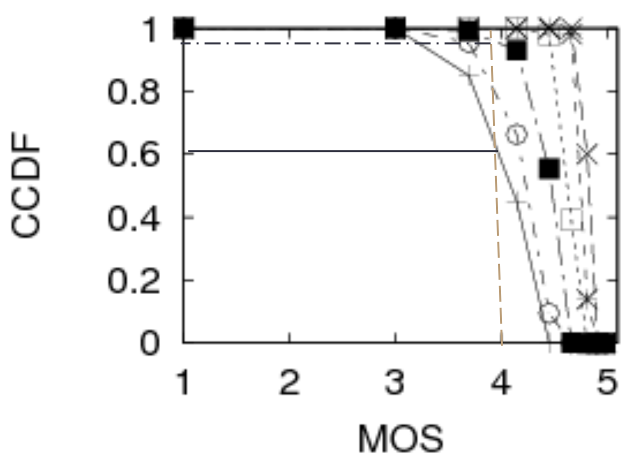
# Results - Individual performance with resource and distance variation



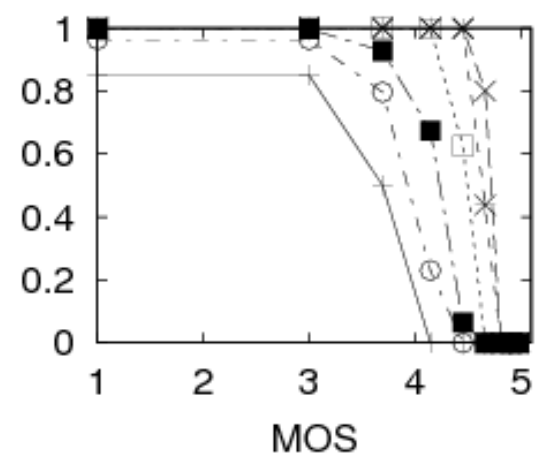

ρ=1.0




ρ=0.8

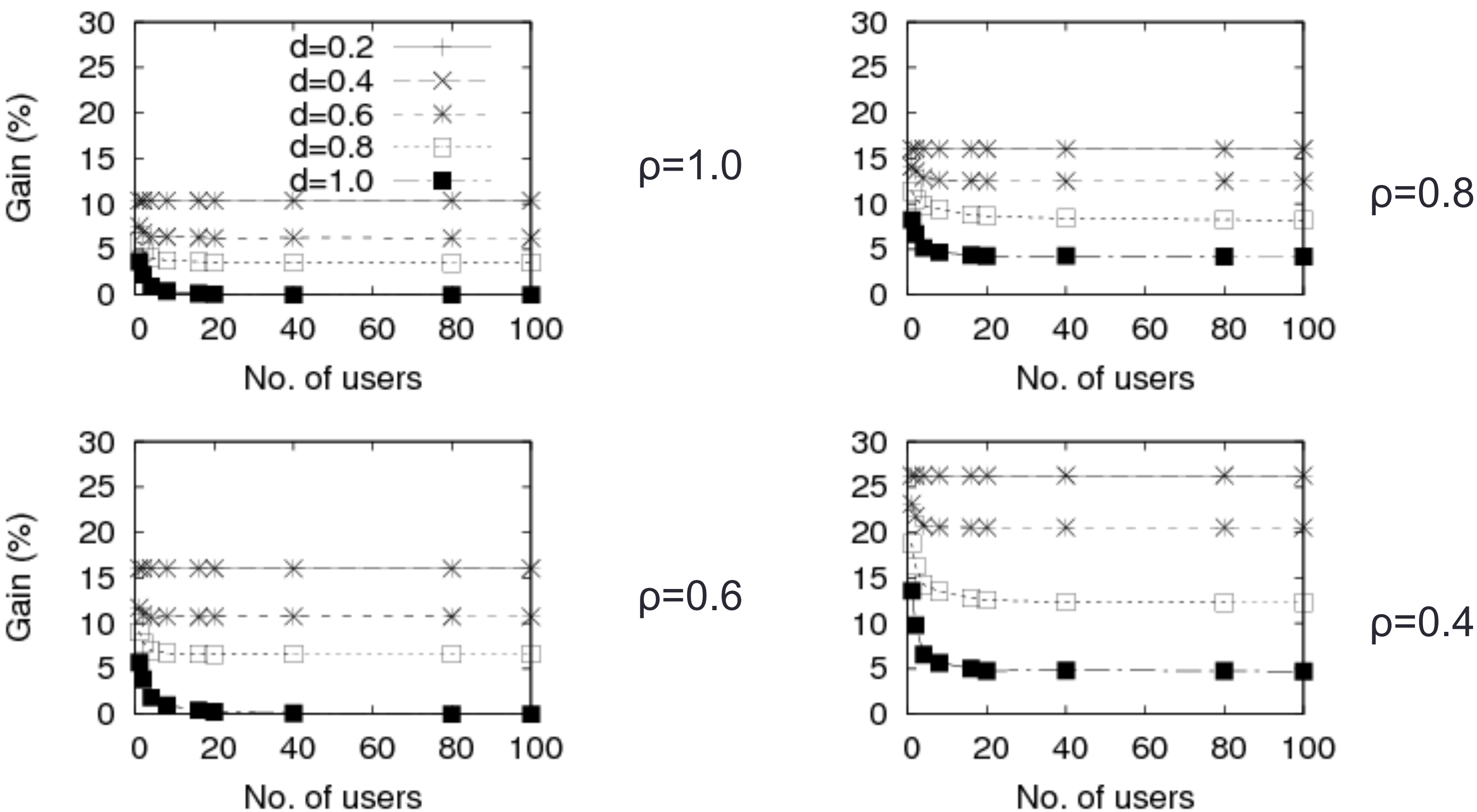



ρ=0.6




ρ=0.4

# Results - Overall performance



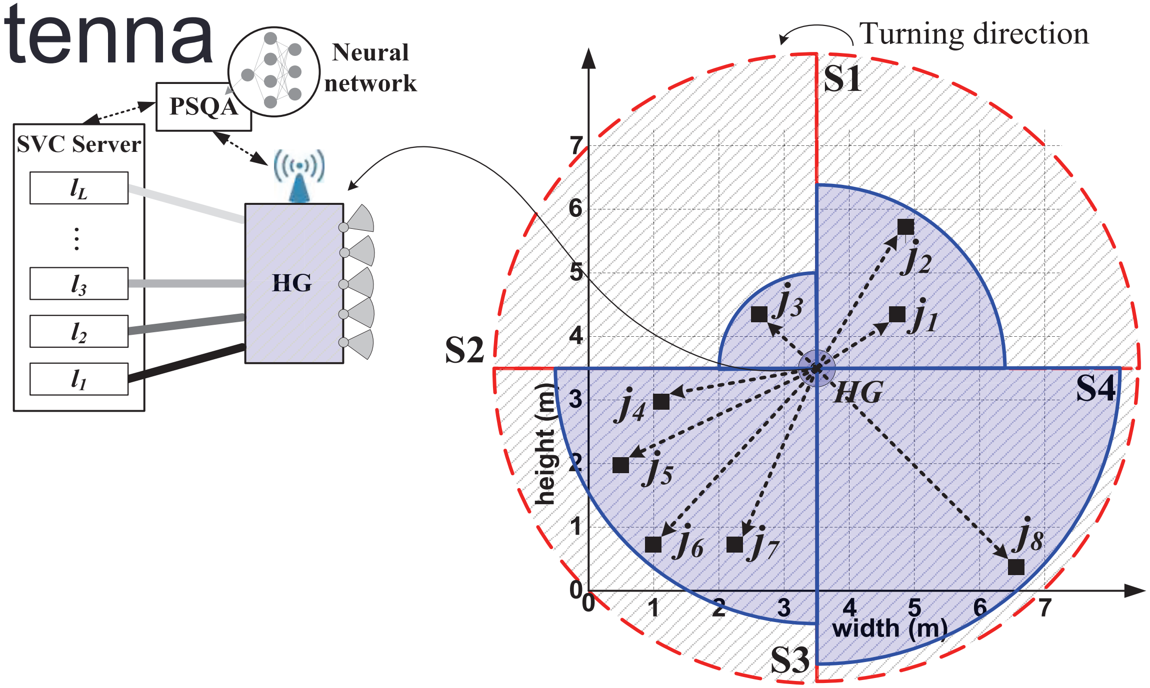

QoE gain is defined as 100 · Qopt/Qref −100

# Conclusions

- Mechanism that  optimizes **QoE** for **SVC** in **wireless multicast** environment
- Performance improvement in terms of quantified overall QoE as compared to the default basic-rate and adaptive-layer approach
- The mechanism also includes the possibility of adapting the QoE objective according to the available resources

# Future works

- Improve QoE estimation with loss
- Study impact on energy
- Combining this strategy with beam switching in directional antenna



# THANK YOU FOR YOUR ATTENTION

Any question?