Optimized Joint Unicast-Multicast Panoramic Video Streaming in Cellular Networks

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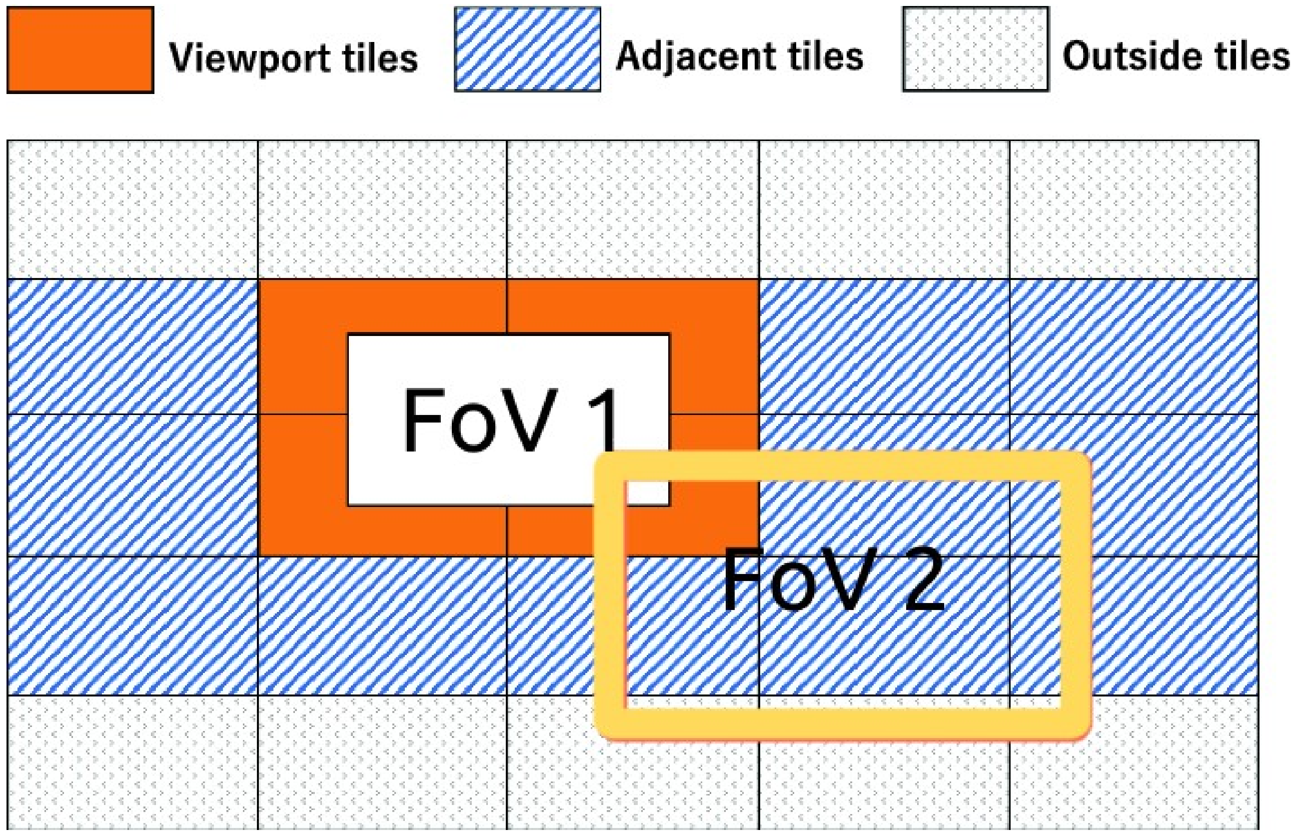
Panoramic video

The advance in Virtual reality (VR) and Augmented reality (AR) technologies fuels the popularity of panoramic media.

Problem Statement

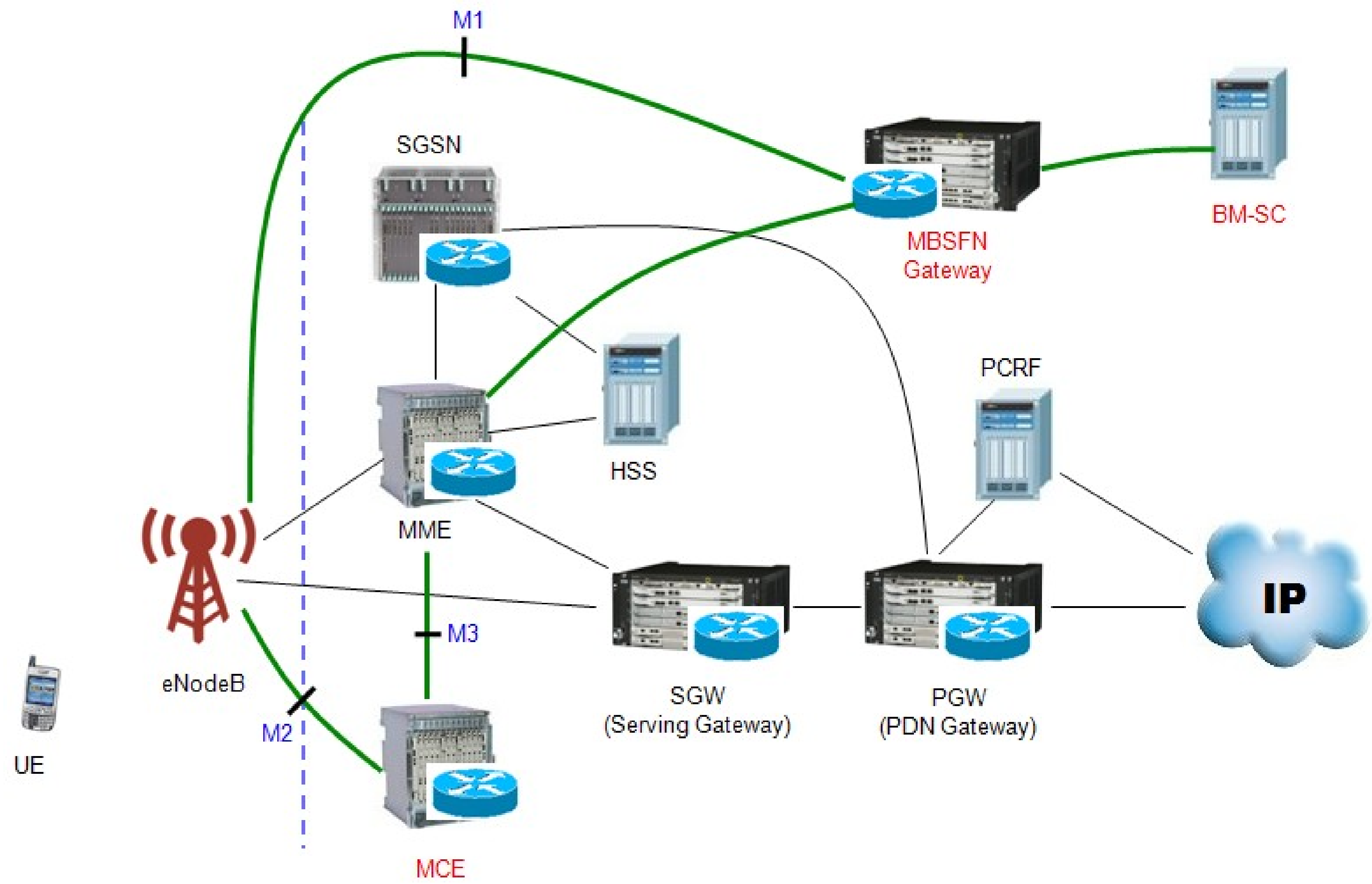
Requires using Ultra-HD resolutions, e.g., 4K and above.
High data-rate requirements than traditional videos.

Motivation



Tiles are encoded independently
FoV is different across users
Diversity in FoV motivates to use joint unicast and multicast.
Multicasting all tiles could lead to inefficient use of resources.

Multimedia Broadcast Multicast Service



Standardize the architecture.

The content is delivered over one or more base stations (BS) .

A Multicast Coordination Entity (MCE).

JUMPS Optimization

Objective => maximizing the total user experience

Const 1=>ensure resources are limited to the available resources.

Const 2 => ensure every user receives every tile only once

The objective and constraints are linear in the problem binary variables. Thus, it can be solved using integer programming solvers.

JUMPS Operation

Solution offers:

Multicasted tiles and their corresponding quality

Unicasted tile for every user and corresponding quality

Result:

Number of RBs would be smaller than the total number of allocated RBs.

It is expected to reduce user battery consumption as users listen to fewer RBs.

Simulation Setup

Num. of users	5,10,20,40,80
Panorama bitrates	6, 8, 10, 14 (Mbps)
Panorama resolution	3840×2160
Tiling configuration	8×8
Group CQI	B:[2-7] | G:[8-15]
spectral efficiency (bits/RB)	[20, 31, 50, 79, 116, 155, 195, 253, 318, 360, 439, 515, 597, 675, 733]
PoV CoV	D:(0.5, 0.2) | F:(0.25, 0.1)
η	L:1.1 | A:1.5

Performance evaluation is based on a custom-built using Python.
We compare JUMPS with the resource assignment algorithm of VRCast.
We solve our optimization problem with Gurobi 9.0 Solver.
Our reported results represent the outcome of 50 runs.

1) Eltobgy, Omar, Omar Arafa, and Mohamed Hefeeda. "Mobile Streaming of Live 360-Degree Videos." IEEE Transactions on Multimedia (2020).

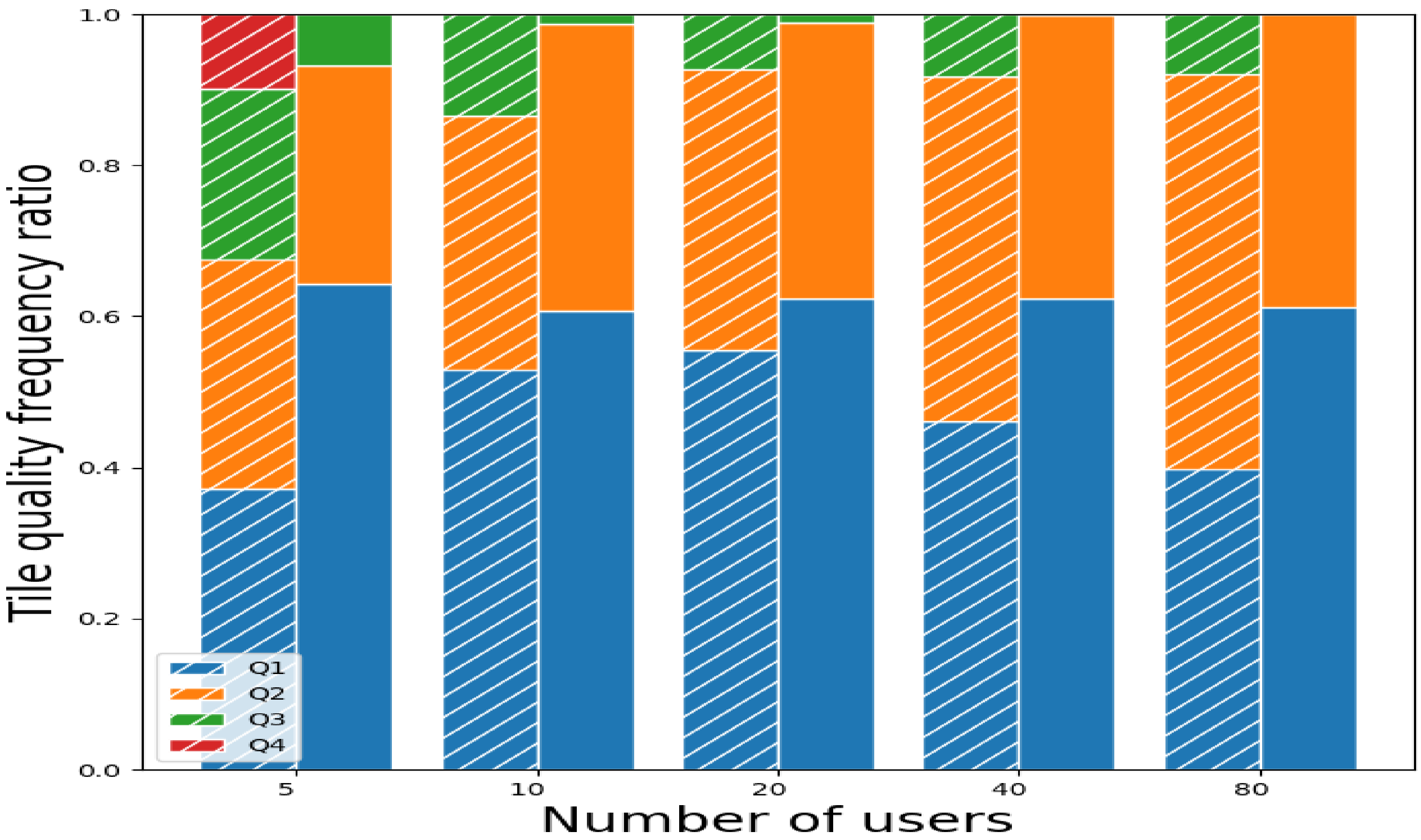
Performance Evaluation Scenarios

MISL

We present the results for the following scenarios:

- Users with Diversified FoV, Weak Link Condition, and Limited resource network (**DWL**)
- Users with Diversified FoV, Good Link Condition, and Limited resource network (**DGL**)
- Users with Diversified FoV, Weak Link Condition, and Abundant resource network (**DWA**)
- Users with Focused FoV, Good Link Condition, and Limited resource network (**FGL**)

DWL Scenario Results



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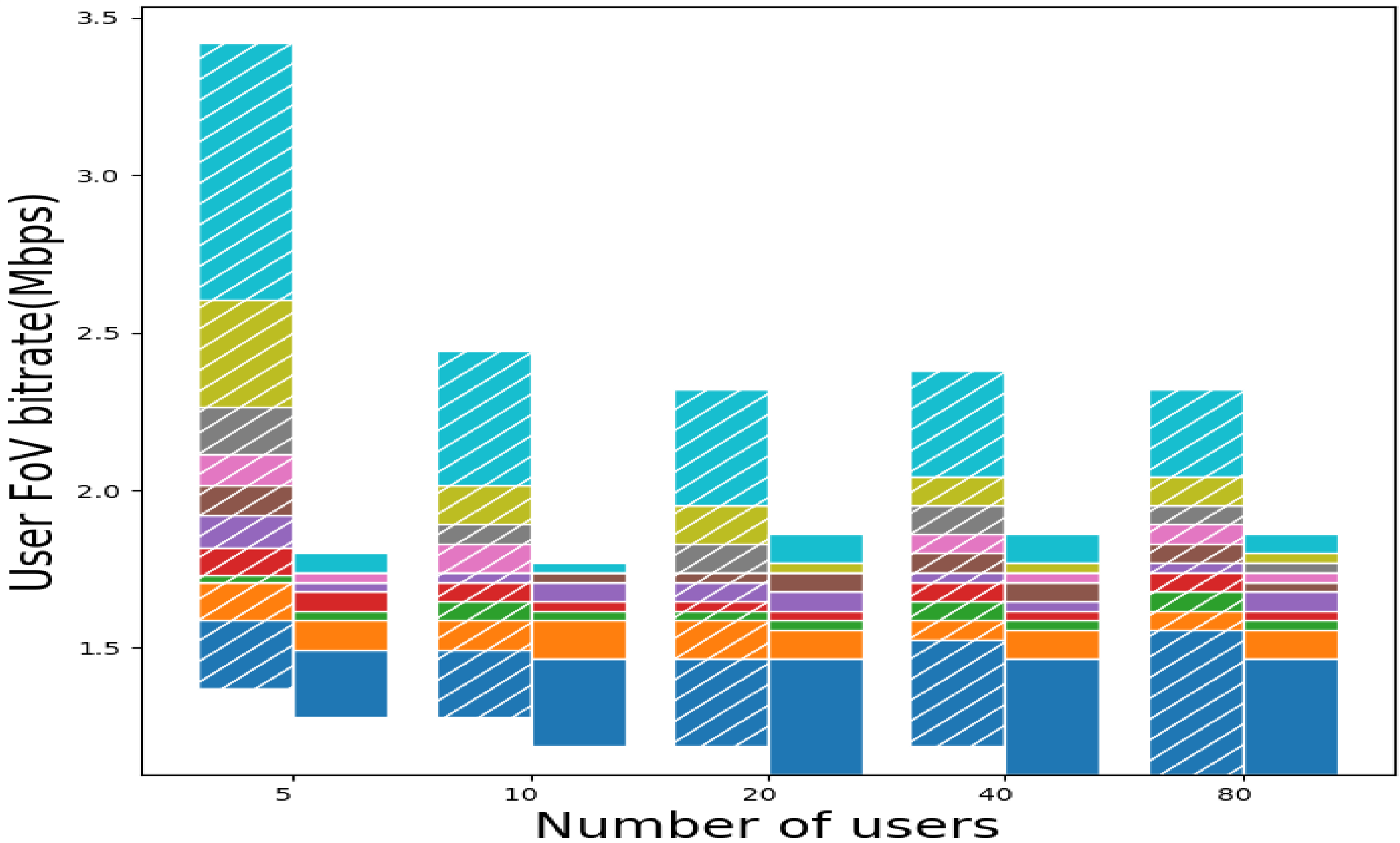
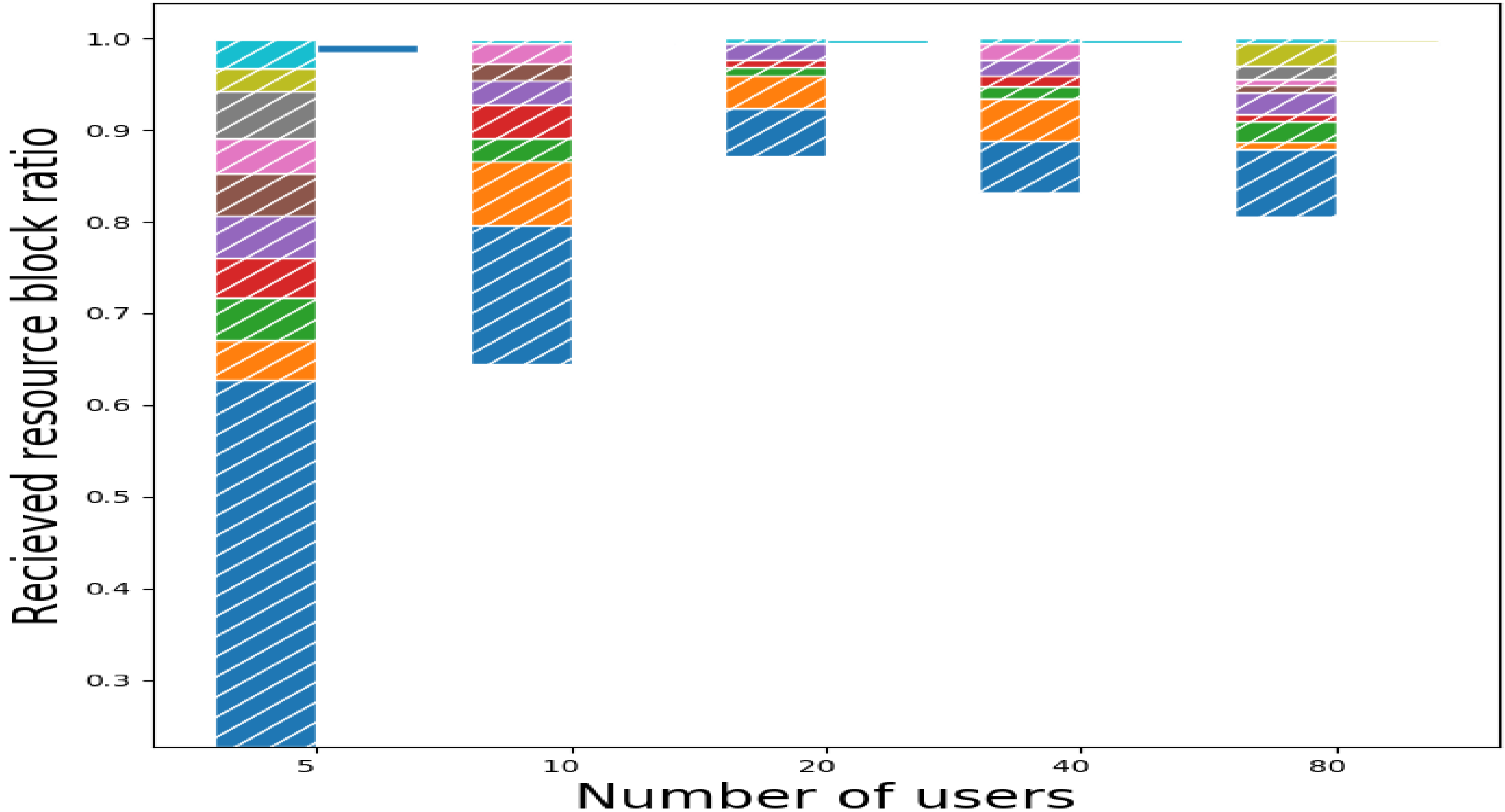
DWL Scenario Result

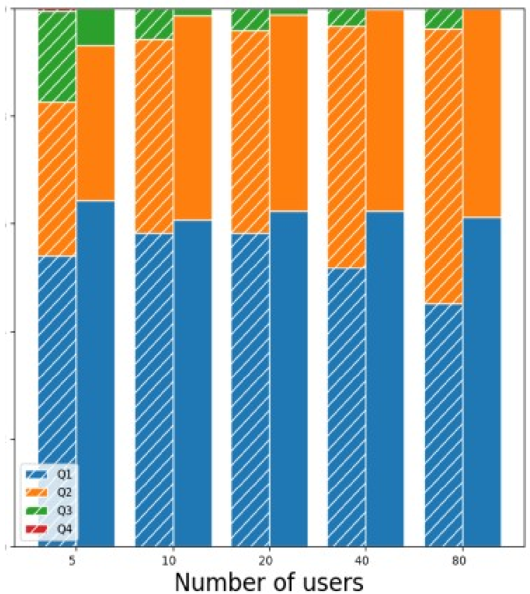


DWL Scenario Result

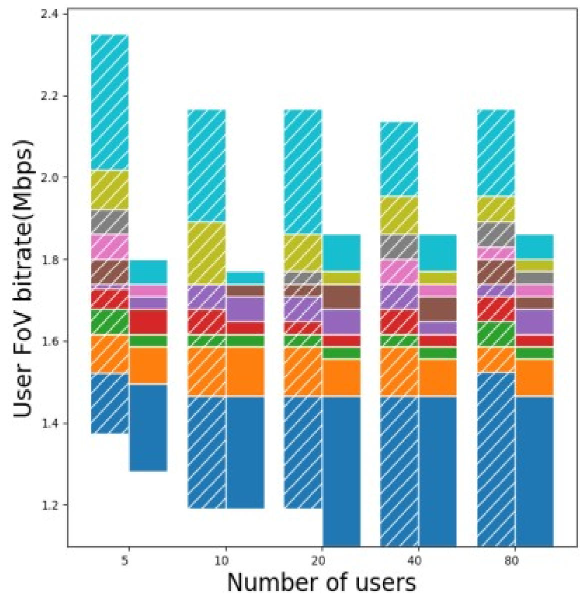


DGL Scenario Results

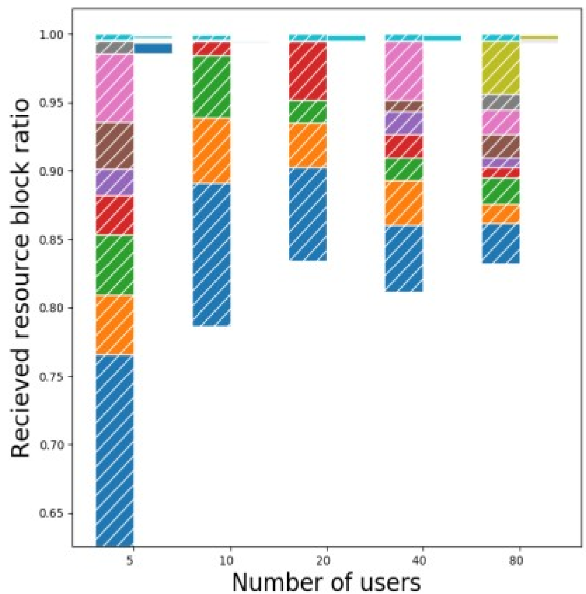
MISL



(a) Tile quality frequency.



(b) User FoV bitrate



(c) Receieved Resource Blocks

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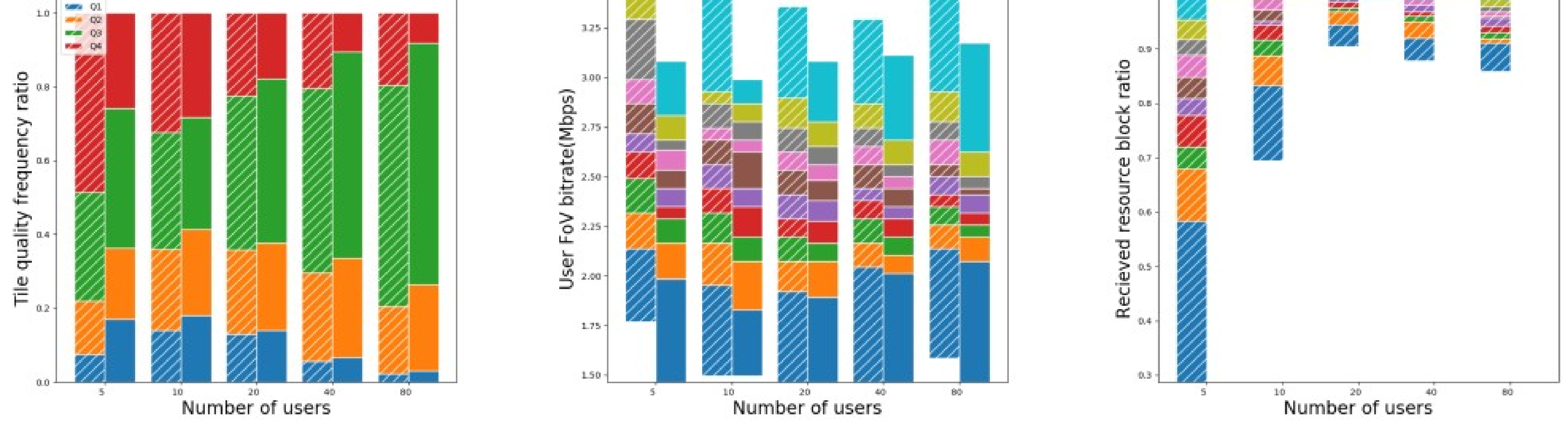
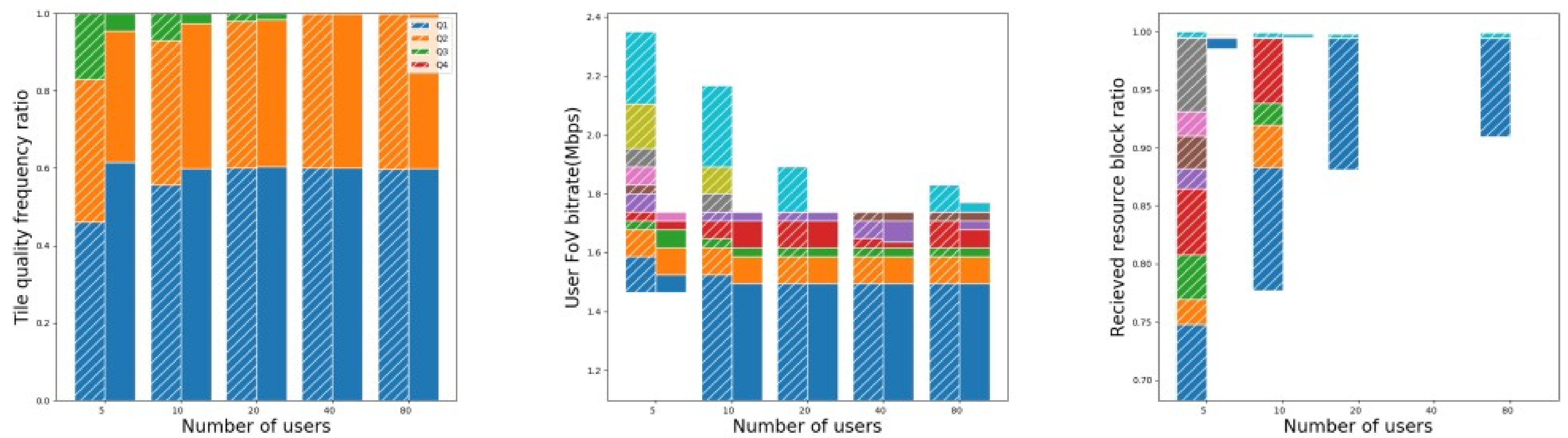


(a) Tile quality frequency.

(b) User FoV bitrate

(c) Receieved Resource Blocks

Fig. 3: Performance Results for DWA scenario. JUMPS uses hashed bars while solid bars represent VRCast.



(a) Tile quality frequency.

(b) User FoV bitrate

(c) Receieved Resource Blocks

Fig. 4: Performance Results for FGL scenario. JUMPS uses hashed bars while solid bars represent VRCast.

Conclusion

A new resource management scheme for delivering popular panoramic content to user groups in cellular systems.

JUMPS exploits both unicast and multicast to improve system.

Our evaluation shows that JUMPS always significantly improves the performance

For larger groups, JUMPS maintains high-performance.

As future work, we consider generalizing JUMPS to manage cellular resources for multiple user groups and multiple base stations (SFN case).

Thank you !