Traffic Reduction for Multiple Users in Multi-view Video Streaming

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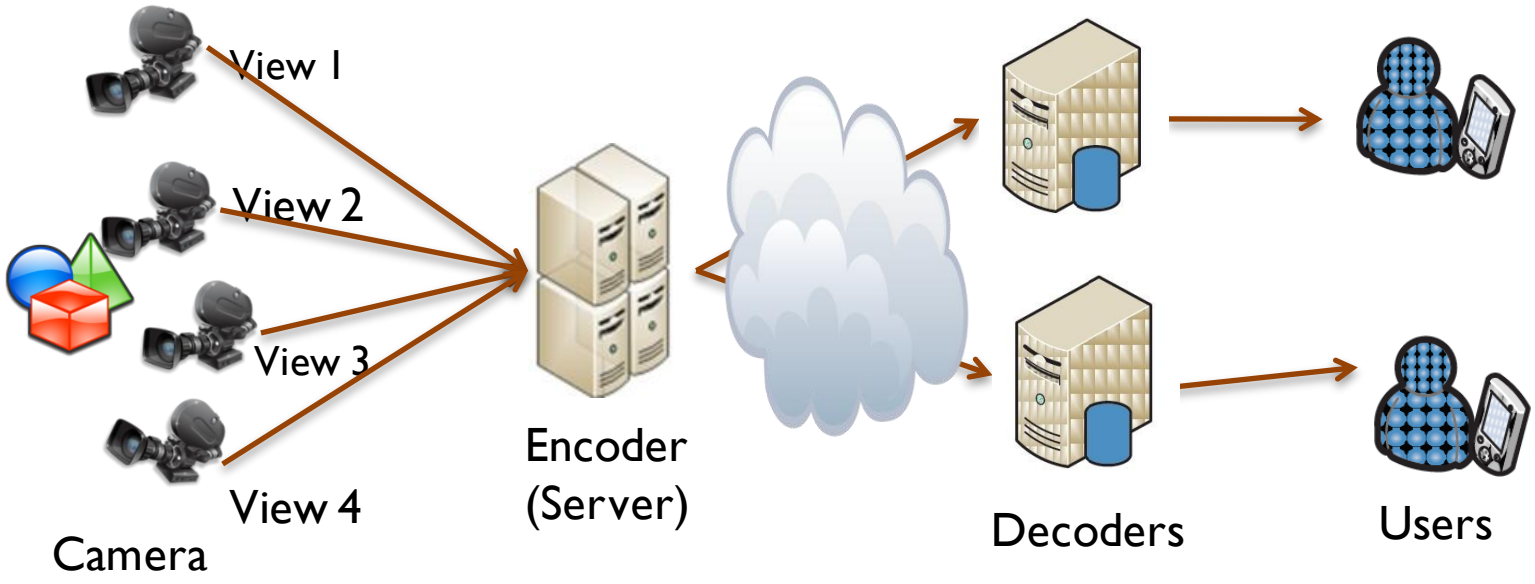
1.1 Background

- Multi-view Video (MVV)
  - Multiple videos taken by multiple cameras
  - Free viewpoint switching

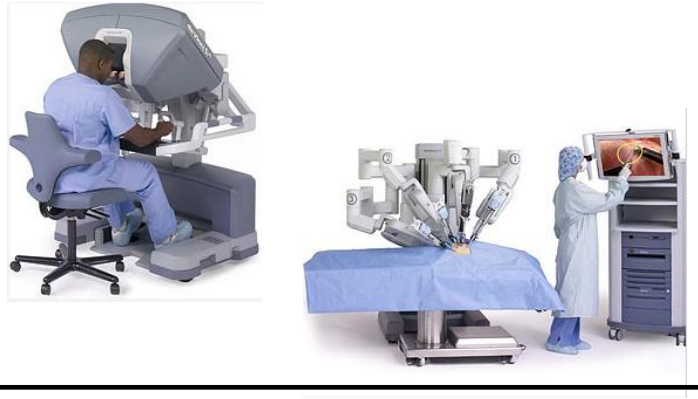


1.2 Background

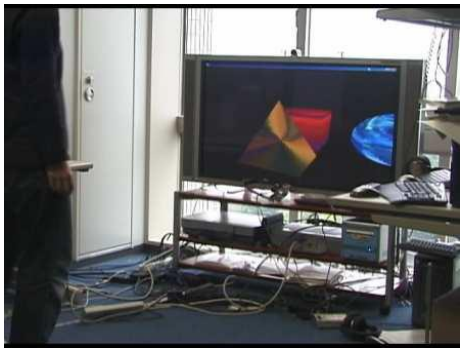
- Applications

Security Monitoring

Remote Surgery



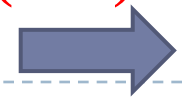
Entertainment（Free View-point TV [1]）



[1] Masayuki Tanimoto, ” FTV: Free-viewpoint Television”, IEEE ComSoc MMTC E-Letter, vol. 6, no. 8, pp. 29-31, Aug. 2011.

2. Motivation and Goal

- Issues of MVV streaming
  1. Traffic
     - Traffic reduction for single user : MVC (H.264/AVC), UDMVT [2]
     - Traffic reduction for multiple users
  2. QoS (Quality of Service)
     - Video quality, Mobility, Real-time
  3. Equipment
     - Placement, Processing capacity
- Goal
  - Reduce the traffic of MVV streaming for multiple users
- Key ideas
  1. Encode the overlapping frame (OFs) once and MULTICAST them
  2. MAXIMIZE the OF area

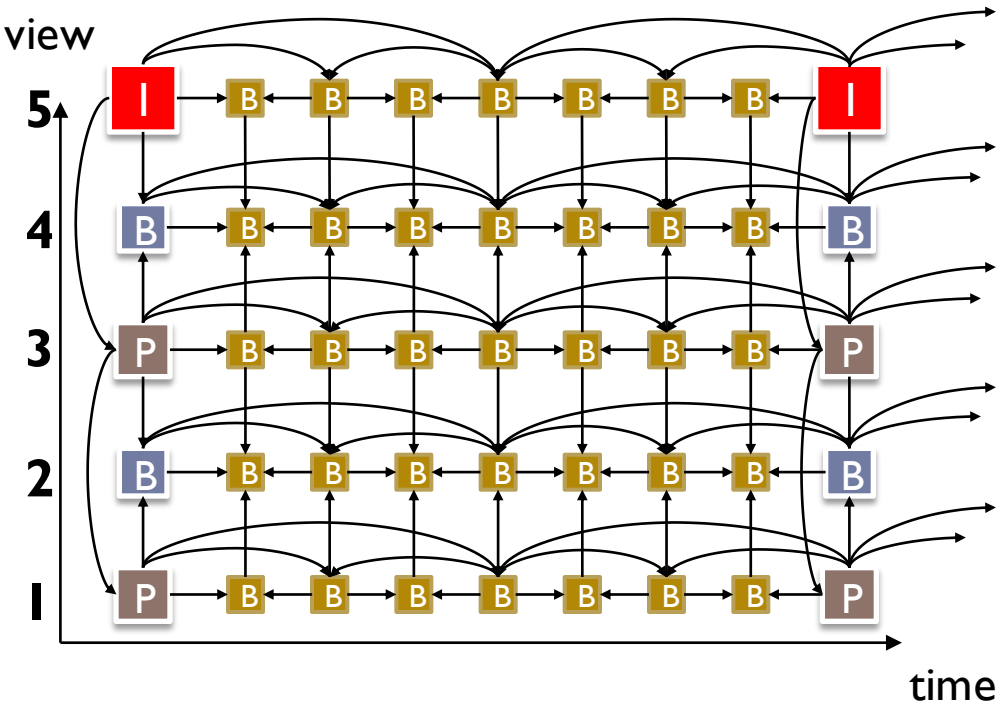


Reduction

[2] Ziyuan Pan, Yoshihisa Ikuta, Masaki Bandai, Takashi Watanabe ”User Dependent Scheme for Multi-view Video Transmission”, IEEE International Conference on Communications, 2011.

3.1 Related Work
H.264/AVC MVC(Multi-view Video Coding) [3]

- Reduce the inter-view correlation by inter-view prediction
- Pros:
  - Remove Inter-view correlation
  - Improve compression ratio
- Cons:
  - Still high traffic
  - Single user

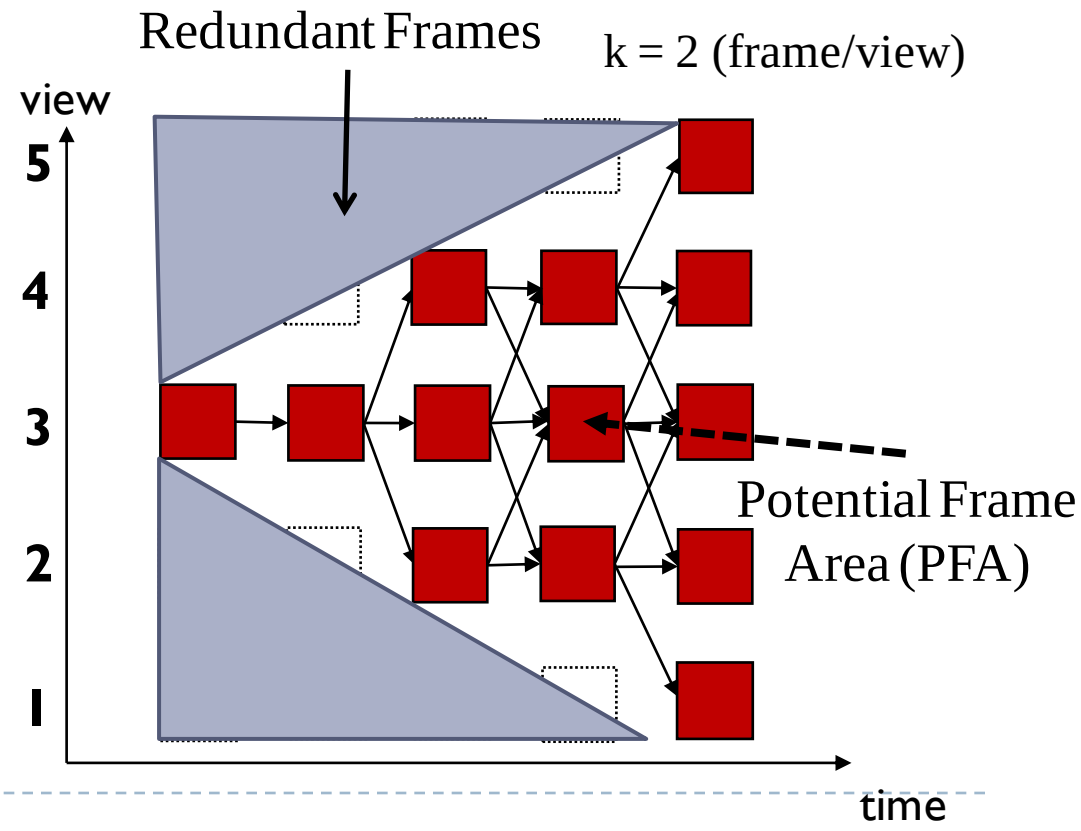


[3] K. Mueller, P. Merkle, H. Schwarz, T. Hinz, A. Smolic, T. Oelbaum, and T. Wiegand, "Multi-view video coding based on H.264/AVC using hierarchical B-frames," IEEE Picture Coding Symposium 2006, 2006.

3.2 Related Work

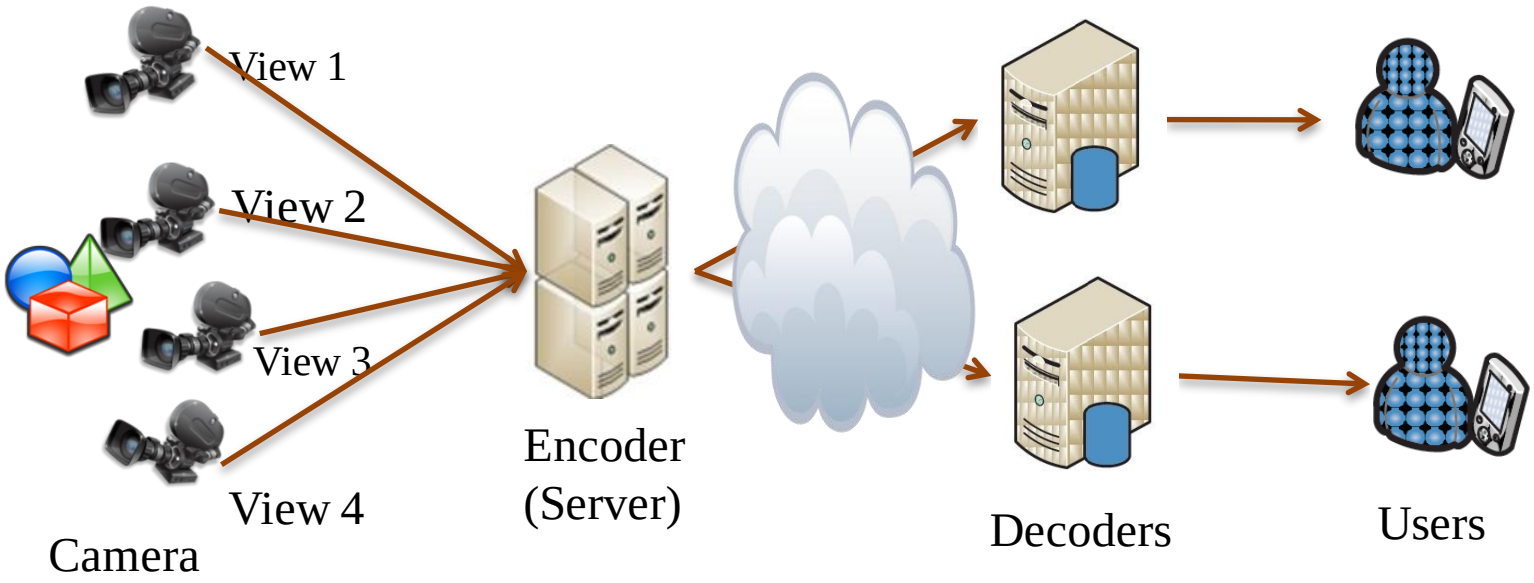
UDMVT(User Dependent Multi-view Video Transmission)[2]

- Only transmit the frames that are possible to be displayed
  - Successive motion model: Switch to neighboring view
    - Periodic feedback : position, frame rate and switching speed
- Pros:
  - Reduce traffic
  - Support live-streaming
- Cons:
  - Single user

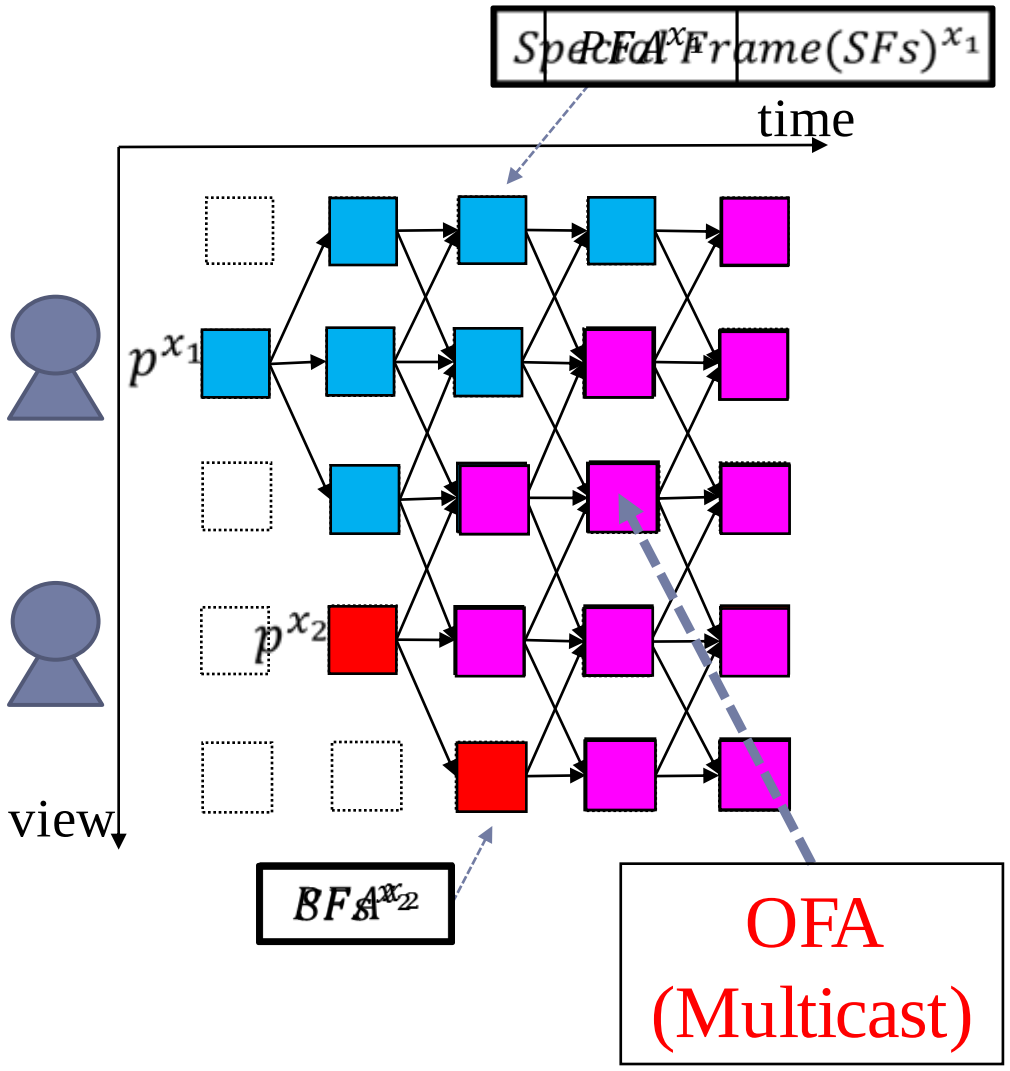


4. Proposed UMSM
(User dependent Multi-view video Streaming for Multi-users)

- Reduce the transmission of overlapping frames (OFs)
  - From the UDMVT base, the scheme improvements include
  1. Encode the OFs only once
  2. Multicast the OFs to multiple users
  3. Maximize the OF area



4.1 Multicasting the OFs



- Predict the PFA of user x by periodic feedback $N^x(p^x, f, s^x)$

  p^x : Initial frame of user x
  f : Frame rate
  s^x : Switching speed of user x

- Calculate the OF area (OFA)

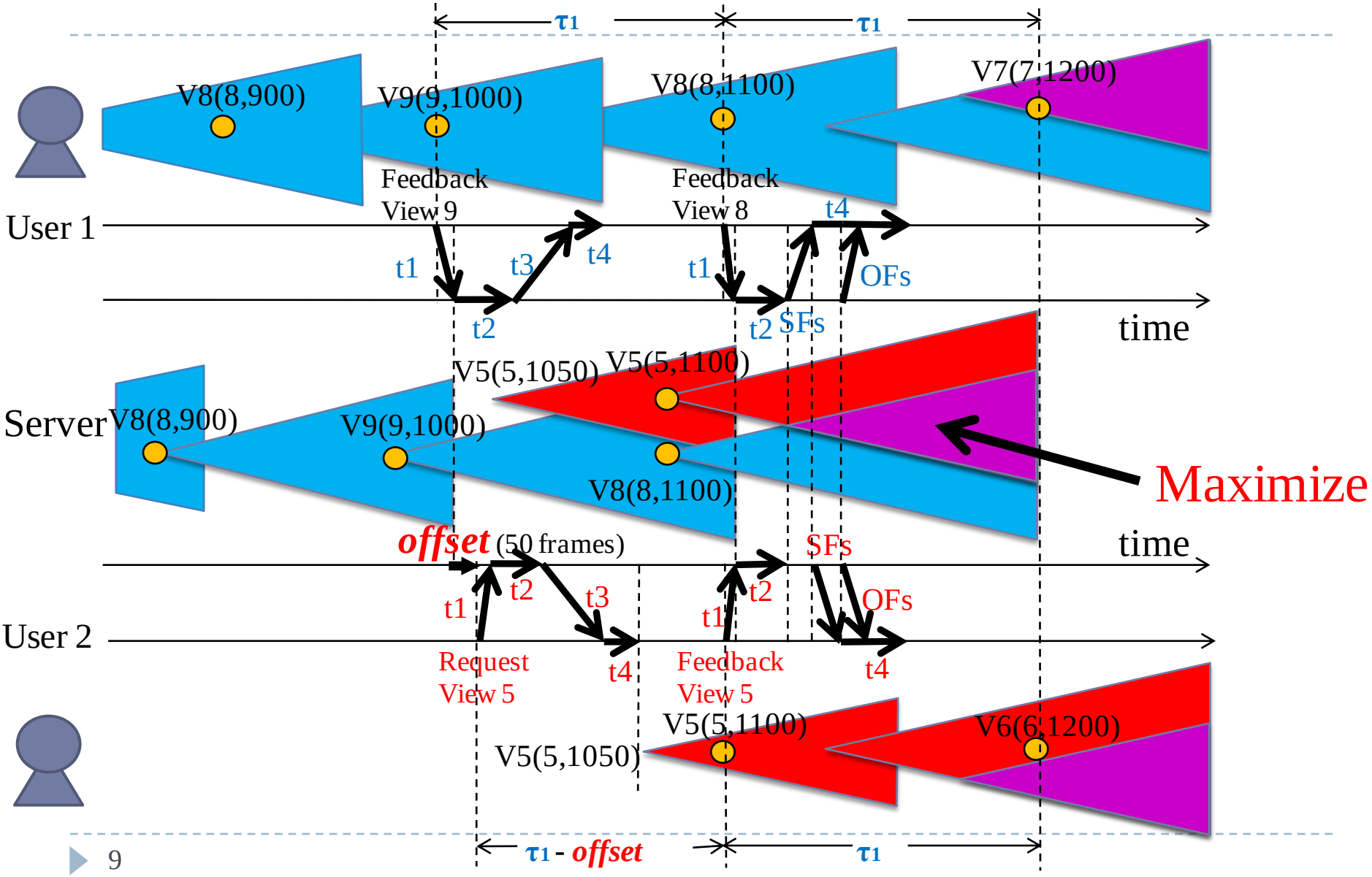
$$OFA(x_1, x_2) = PFA^{x_1} \cap PFA^{x_2}$$

- Transmission of each frame

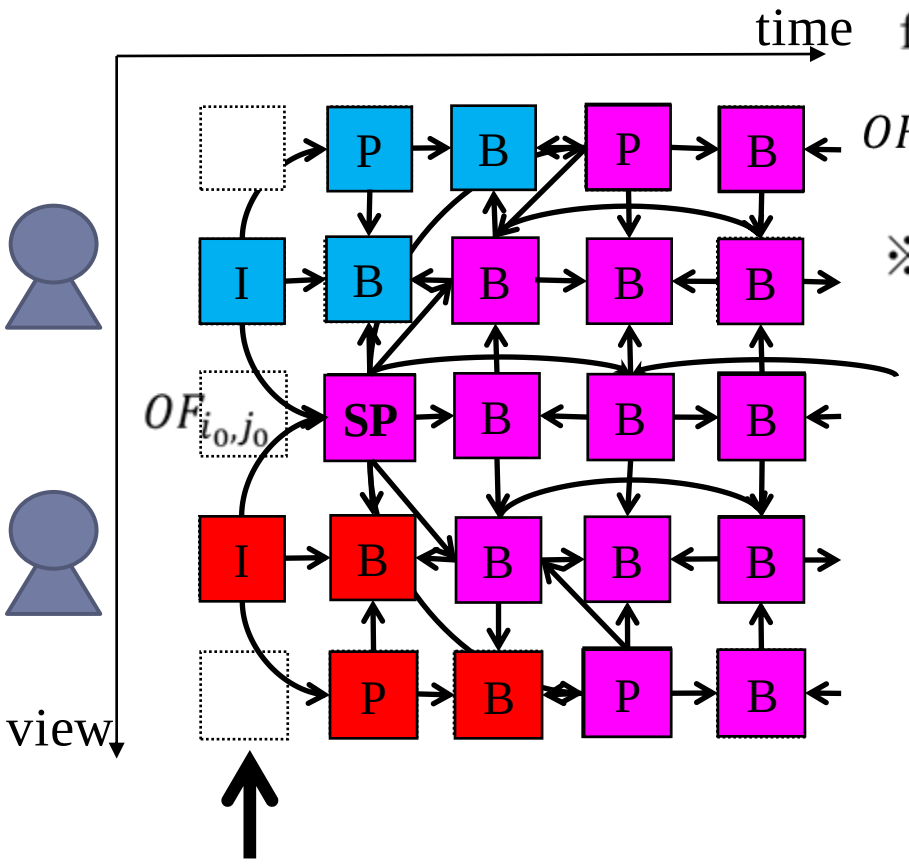
1. Multicast the OFs to multiple users
2. Unicast the SFs to each user

4.2 Encoding and Maximizing the OFs

τ_1: Feedback Period (100 frames)



4.3 Prediction Structure (After Alignment)



First frame of the OFs (OF_{i_0,j_0})is encoded as follows:

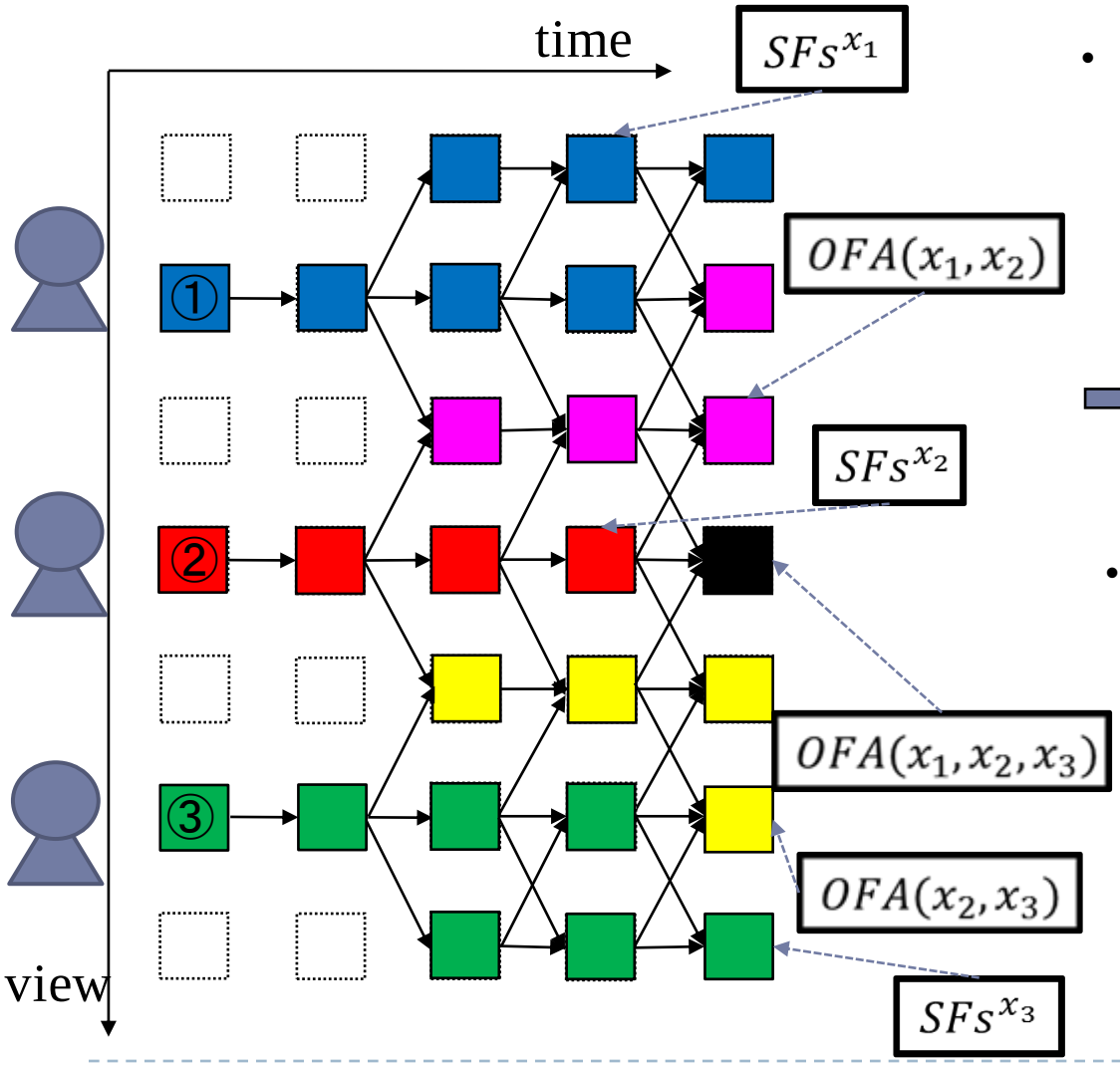
$$OF_{i_0,j_0} = \begin{cases} I-frame\ if\ F^x{}_{i_0,j_0} \in PFA^{x'}, x \neq x' \\ SP-frame\ \ else \end{cases}$$

※ $F^x{}_{i_0,j_0} \in PFA^x$: First frame of the user x's PFA

Prediction structure of UMSM

1. *OFs* are predicted from other *OFs*
2. *SFs* of a user are predicted from the *OFs* and *SFs* of that user

4.4 Problem of UMSM



- Many OFs are generated and transmitted as the number of users increases

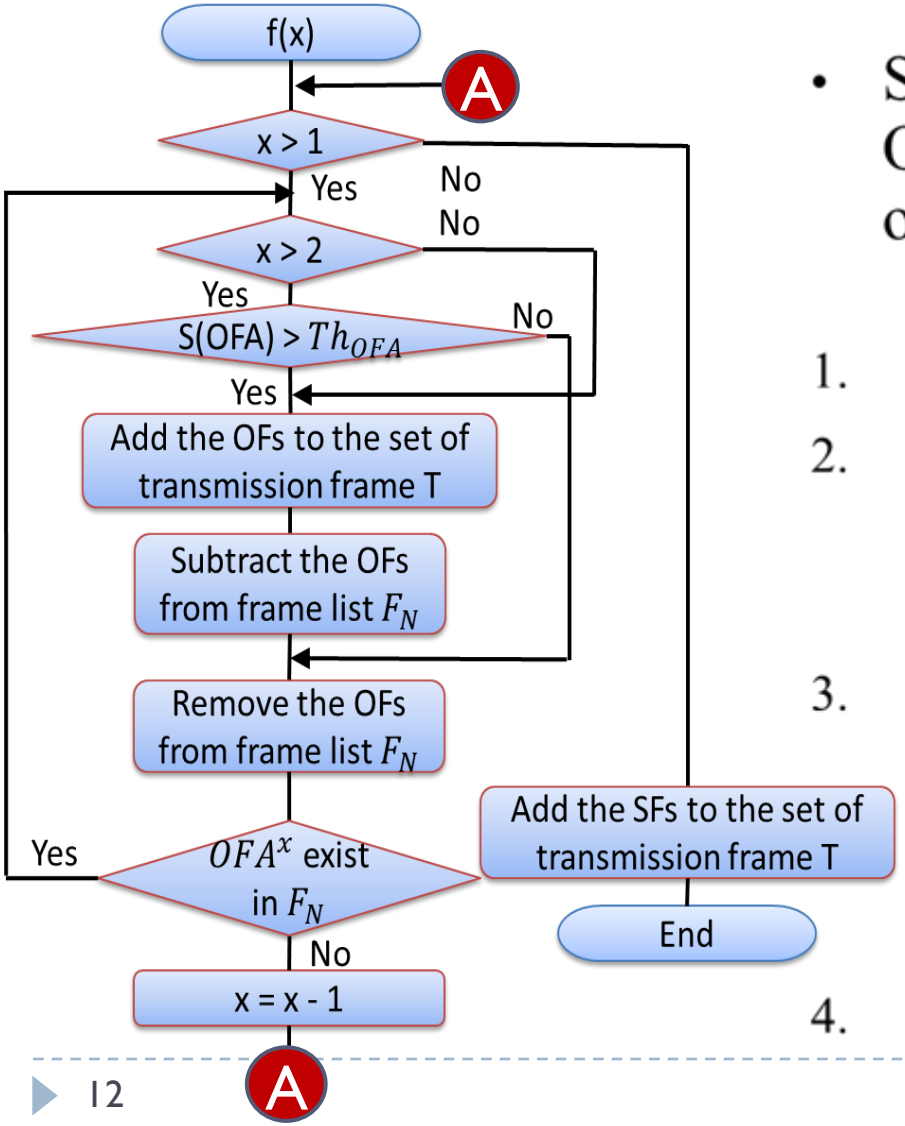
  $OFA(x_{m,}\, x_n)$: multicast to user x_m and x_n

⇒ Many transmissions will overwhelm the router [4]

- Propose an algorithm to discuss the trade-off between traffic and transmissions

[4] Baoxian Zhang, Jun Zheng Hussein T. Mouftah"A scalable multicast routing protocol for building shortest path trees", 2007 IJCS Trans., vol. 20, no. 8, pp. 993-1009, Aug. 2007.

4.5 Proposed Algorithm



- Suppress the transmissions of OFs depending on the threshold of size of OFA (called Th_{OFA})

1. Initialize x ← N (Number of users)
2. When the size of OFA for x is greater than Th_{OFA}
   ➡ Multicast the OFs
3. When the size of OFA for x is less than Th_{OFA}
   ➡ Try to multicast large brocks of OFs
4. x ← x-1, recurse to step 2

5. Evaluation Setting

- Evaluate the traffic of MVC, UDMVT and UMSM.
- Encoder : JMVM
  - Joint Video Team of ITU-T VCEG and ISO/IEC MPEG. JMVC software.
- Video sequence : Ballroom
  - ISO/IEC JTC1/SC29/WG11, "Multiview Video Test Sequences from MERL", Doc.M12077, Busan.Korea.

Ballroom (640 * 480)

Simulation Parameters

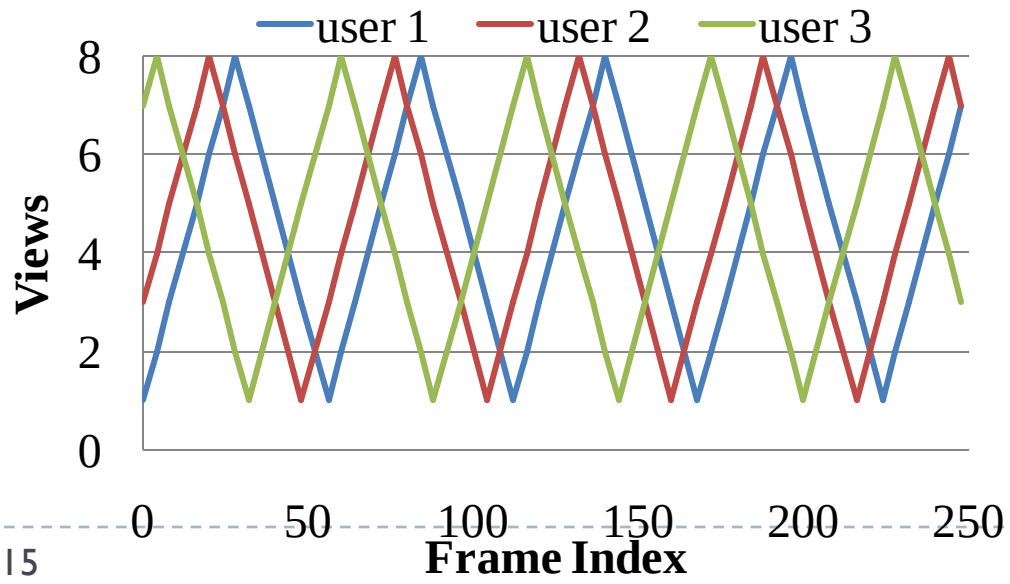
Video sequence	Ballroom
Number of views	8
Frame rate	25 fps
Number of frames	250 frames
Number of users	1~10
Feedback period	8
Value of k	5
References	MVC, UDMVT, UMSM

5.1 Switching Mode

- Define 3 types of switching mode
  - Scanning
  - Watching
  - Random

5.1.1 Switching Mode (Scanning)

- User 1 starts from view 1
  - Switch from view 1 to view 8
  - Alter the direction to view 1
  - Repeat this cycle
- User 2 and 3 have the same cycle with different phases



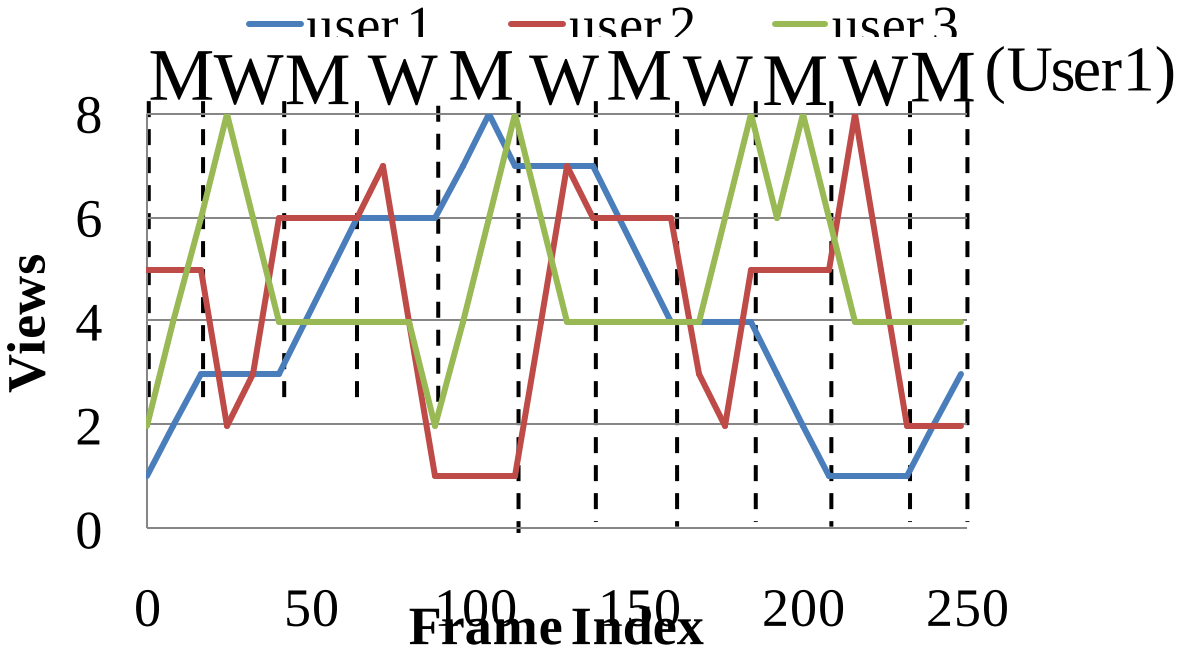
User 1

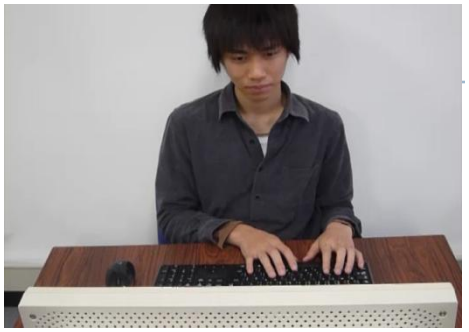
User 2

User 3

5.1.2 Switching Mode (Watching)

- 2 types of phases:
  - Moving phase (M)
  - Watching phase (W)





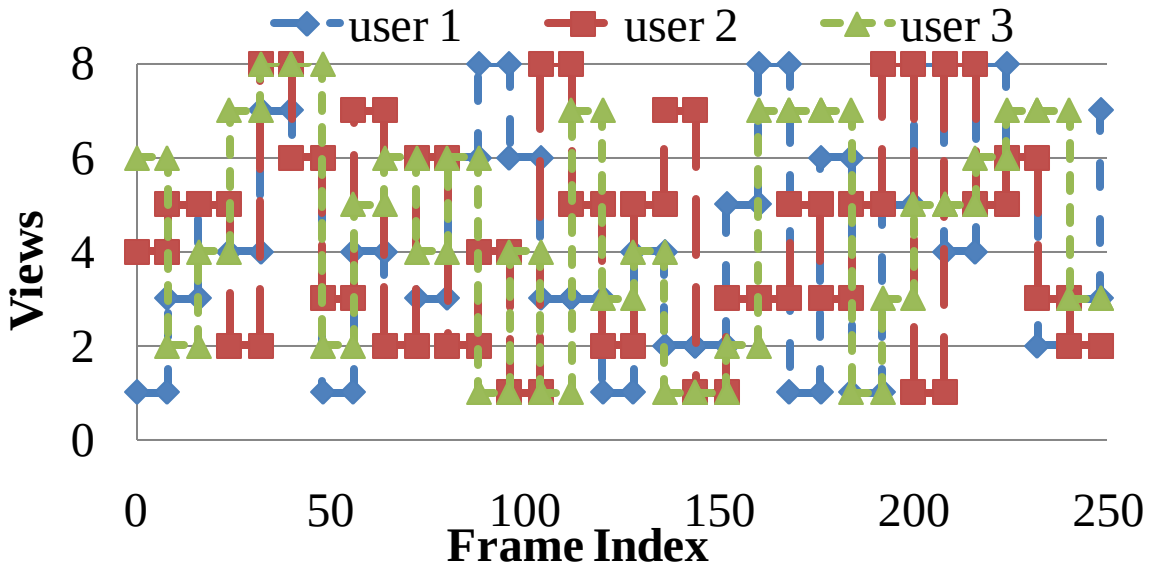
User 1

User 2

User 3

5.1.3 Switching Mode (Random)

- Switch views randomly
- Transmit all the views

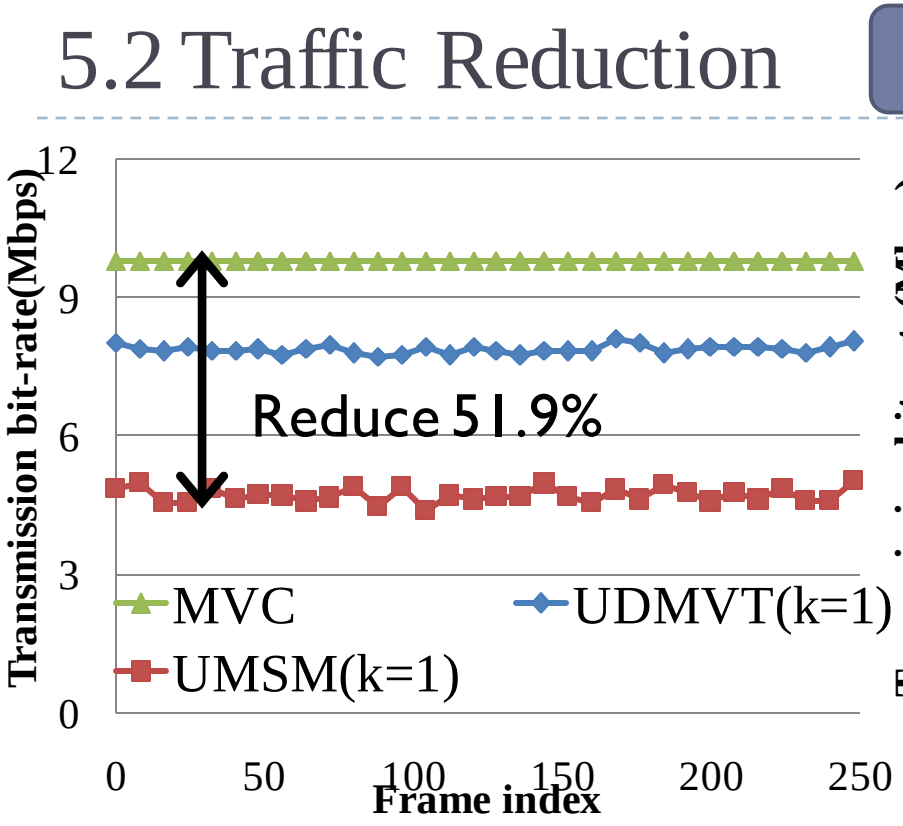


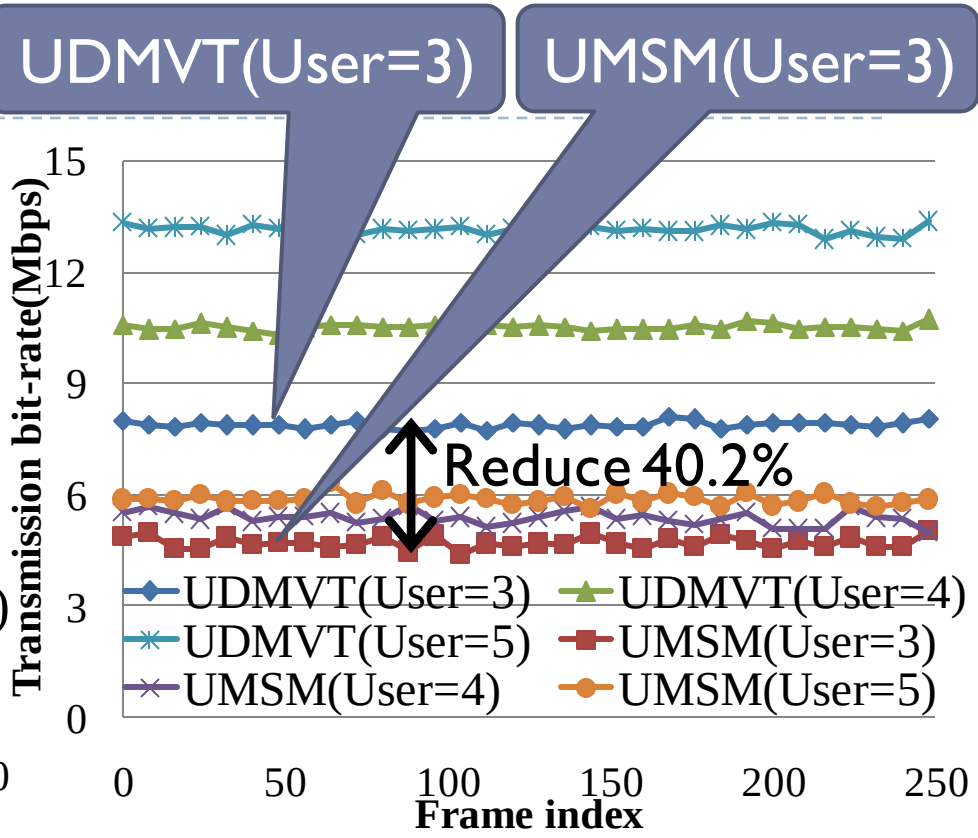
User 1

User 2

User 3

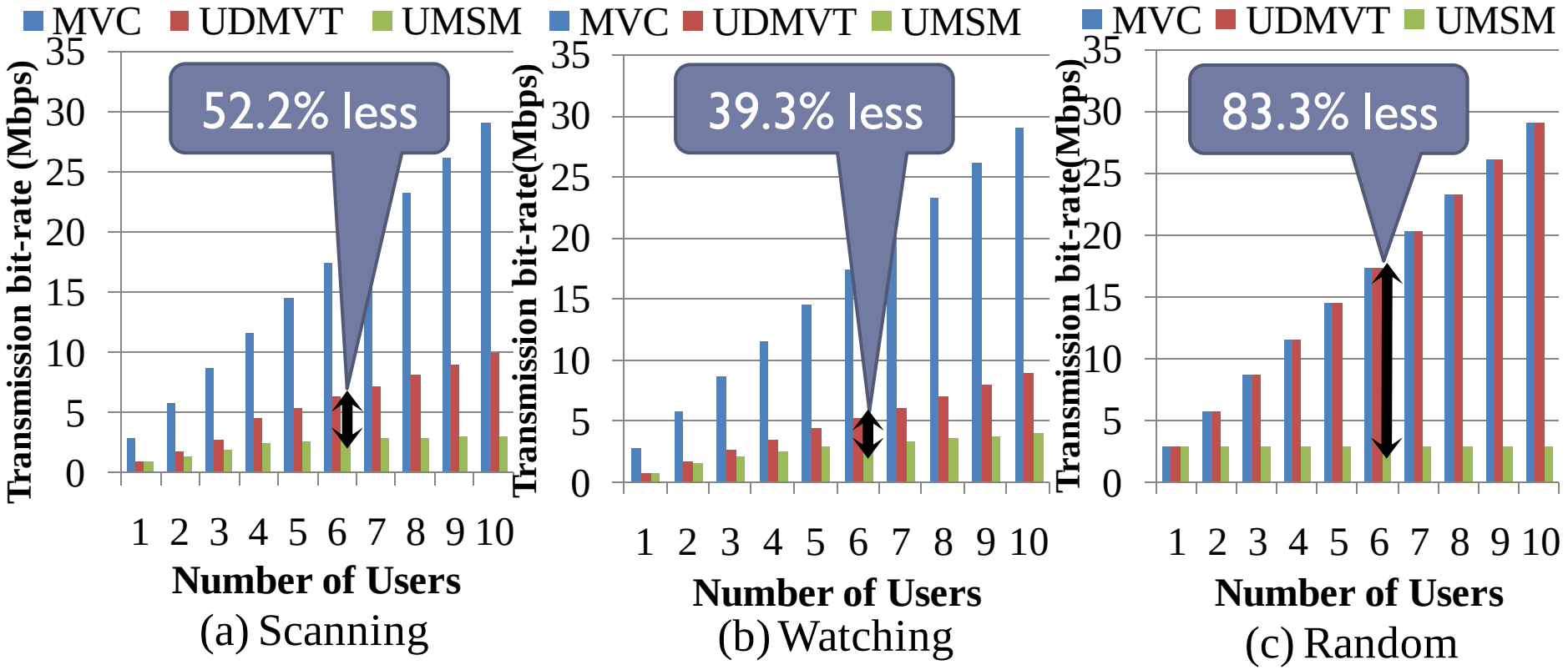
5.2 Traffic Reduction





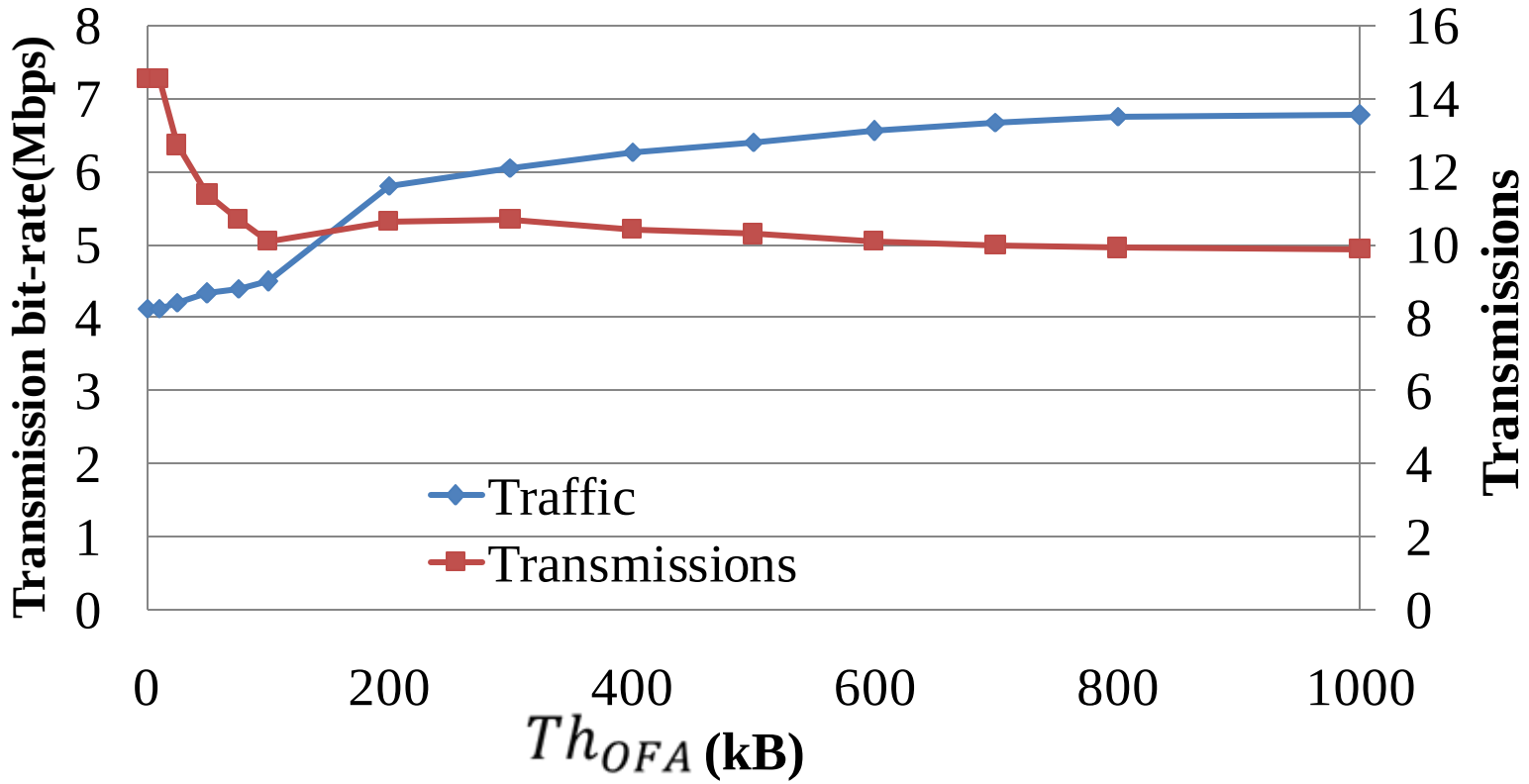
- Proposed UMSM reduces more traffic than existing work
  - 3 users → 51.9% less than MVC
  - 3 users → 40.2% less than UDMVT

5.3 Traffic Reduction (Switching Mode)



- Proposed UMSM reduces the traffic depending on modes
  - 6 users → 52.2% less than UDMVT with the scanning mode
  - 6 users → 39.3% less than UDMVT with the watching mode

5.4 Number of Transmissions and Traffic

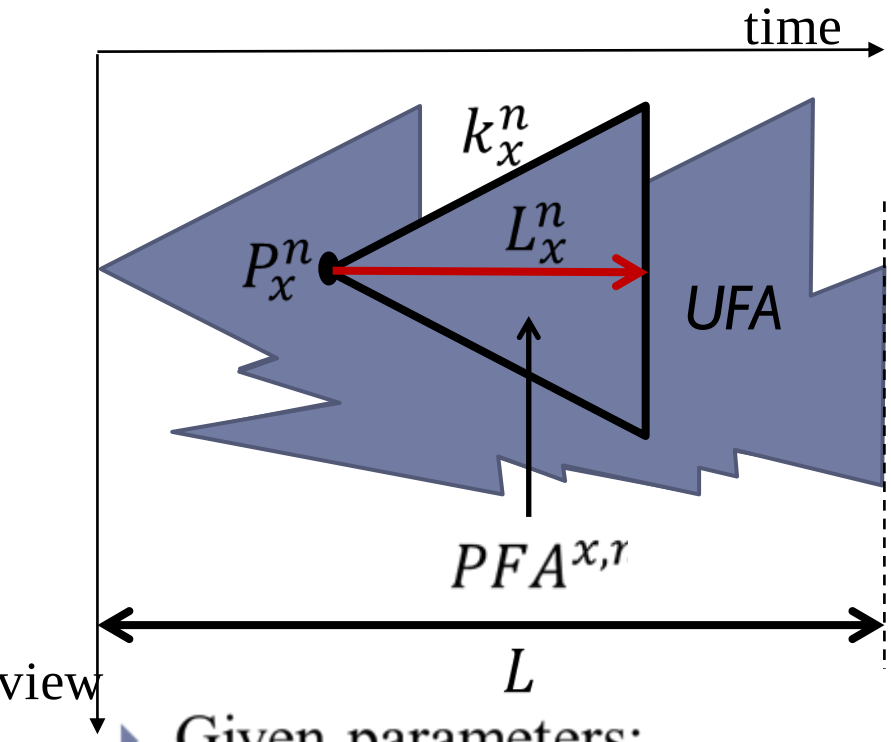


- Discuss the trade−off by changing the value of Th_{OFA}
  - As Th_{OFA} decreases, UMSM reduces the traffic
  - As Th_{OFA} increases, UMSM reduces the transmissions

6. Extended Discussion

- Not in the paper
- Addressing UMSM over general optimization
  - Different switching speeds
  - Different positions
  - Different feedback periods

6.1 UMSM vs. Global Optimization (Not in the paper)



- Union of frames area (UFA) should be minimized until the end of video
  - Optimization problem to maximize the traffic reduction for N users

$$\underset{P_{x,n}}{\operatorname{argmin}}\left(UFA(X)\right) = \cup_{x=1}^{N} \cup_{n=1}^{T} PFA^{x,n}$$

$$subject\ to\ P_{x,n} < L$$

$$X = [PFA^{1,1}, PFA^{1,2}, \dots PFA^{1,T}, PFA^{2,1}, \dots PFA^{2,T}, \dots, PFA^{N,T}]$$

$$PFA^{x,n} = f(P_x^n, k_x^n, L_x^n)$$

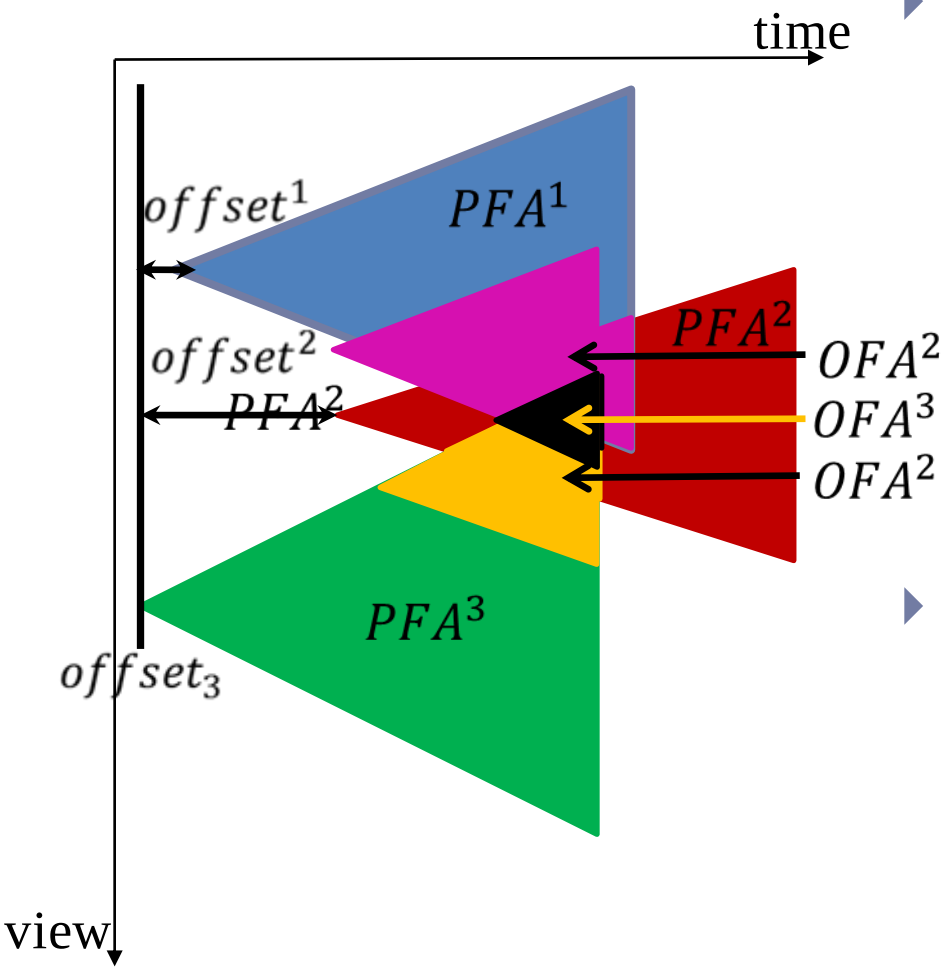
- Given parameters:

N: Number of users, T: Max feedback times, L: Video length,

k_x^n: k of $PFA^{x,n}$, P_x^n: Position of $PFA^{x,n}$, L_x^n: Length of $PFA^{x,n}$

- P_x^n, L_x^n, k_x^n, and T would be unknown in advance

6.2 UMSM Heuristics



- Use the heuristics to solve the problem
  - Maximize all the combinations of 2 users' OFA by aligning the offset (Proven)
- This method is suboptimal
  - Maximize the traffic reduction for N users

7. Conclusion and Future work

- Conclusion
  - Propose UMSM to reduce the traffic of MVV streaming for multiple users
    - Encode the overlapping frame (OFs) only once and multicast them
    - Maximize the area of OFs
  - Evaluation
    - Reduce more traffic than existing work, when there are multiple users
    - Discuss the trade-off between traffic and transmissions
- Future work
  - Develop the MVV streaming for a very large number of users
    - Watch future Olympic games around the world!

Thank you attention!

- Special Thanks
  - Prof. Wilkinson: Oral presentation advice
  - Prof. Kitani: Optimization advice
  - Prof. Saruwatari: Switching mode advice
  - Mr. Aoki, Mr. Sugiyama, Mr. Yamazaki, Mr. Fujikawa: Video clips