14TH ITU ACADEMIC CONFERENCE

ITU KALEIDOSCOPE

ACCRA 2022

Research and standardization requirements for 5G network peak control technology in video transmission

7-9 December 2022

Accra, Ghana

Zhiji DENG
Zhejiang Provincial Key Laboratory of Harmonized Application of Vision & Transmission, China

Xiangyu QU
Zhejiang Dahua Technology Co. Ltd., China

Session 3 – Services in future networks
Paper S3.2

ITU KALEIDOSCOPE
ACCRA 2022

Abstract

Problem

- *Advantages of 5G network in video transmission;*
- *New problems faced by 5G network in video transmission;*
- *Network peak generation analysis.*

Method

5G network peak control technology:

- *Architecture;*
- *I-frame collision detection service;*
- *Network peak scheduling service.*

Effect

- *Application results.*

Thinking

- *Research conclusion;*
- *Standardization consideration.*

Background

The video surveillance service is one of the typical video transmission scenarios.

Advantages of 5G network in video transmission:

- The characteristics of 5G network including large bandwidth, low delay and wide coverage, enable video acquisition devices to access at anytime and anywhere.
- Multi-dimensional data fusion and local storage based on MEC can break data islands and improve data security.

New problems faced by 5G network in video transmission:

- In large-scale deployment, when the 5G network is planned according to the video transmission peak, which will cause a low communication resources utilization. When the 5G network is planned according to the average bandwidth of video transmission, which will cause video transmission freezes at intervals, affect the user experience, and the number of camera accesses cannot meet expectations. When multiple videos are transmitted concurrently in 5G networks, the network peak will fluctuate dramatically.

Network peak generation analysis

Single-channel video transmission scenario:

- The difference between I-frame and P-frame is large, and the data volume ratio can reach more than 10 times.

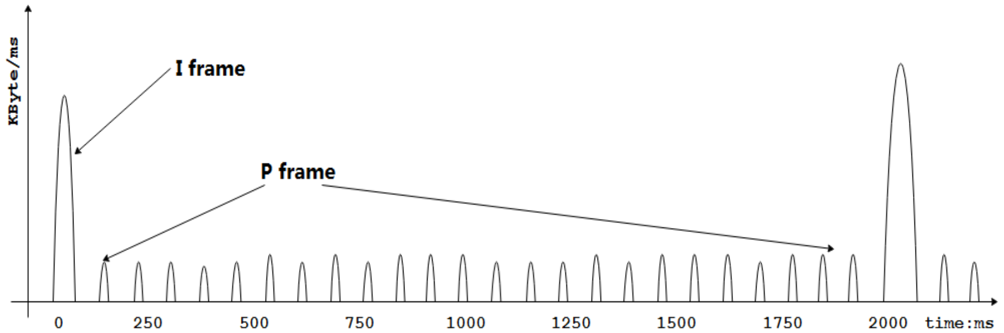

Figure 1 – Real-time streaming video frames (single-channel)

Multi-channel video transmission scenario:

- When multiple channels of video are transmitted concurrently, I-frames may be sent at the same time (I-frame collision), causing severe fluctuations in network peaks.

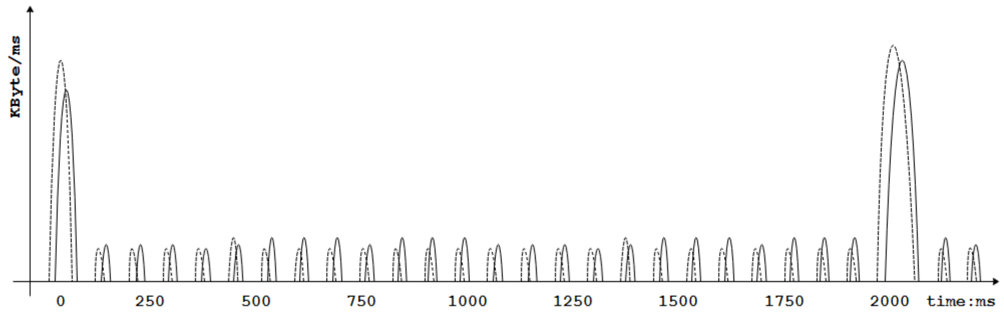

Figure 2 – Real-time streaming video frames (two-channel)

When seven channels of video are transmitted concurrently, the I-frame collision is about 92%.

With the common 5G base station capability of 150M uplink bandwidth, the theoretical number of video transmission paths (calculated according to the 4M code stream of 1080P) is about 36 channels, which is far more than seven channels concurrently, and the I-frame collision will be greater.

ITU KALEIDOSCOPE ACCRA2022

5G network peak control technology – 1 of 3

Architecture

The video management platform obtains 5G base station network data through the MEC, and determines whether there is network congestion caused by I-frame collision.

- The video acquisition devices are surveillance video capture devices such as cameras.
- The 5G access network consists of wireless network facilities such as 5G base stations.
- The MEC connects the 5G wireless network and the video management platform, and provides 5G data forwarding services, I-frame collision detection services, and network peak scheduling services.
- The video management platform provides device management services, streaming media services, network peak control strategy services, etc.

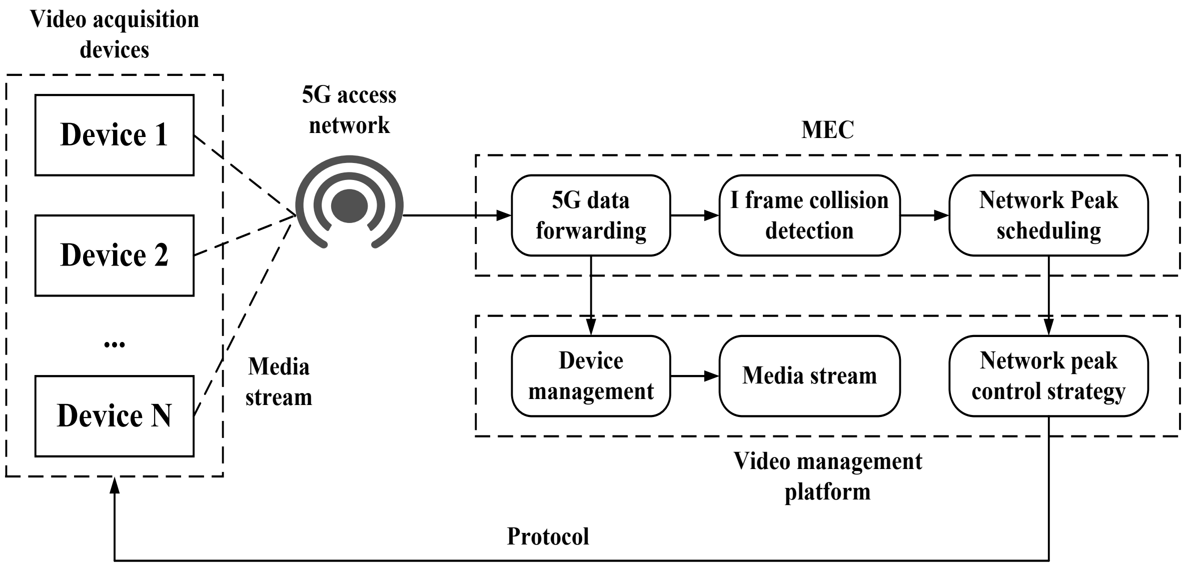

Figure – Architecture of 5G network peak control technology

5G network peak control technology – 2 of 3

I-frame collision detection service

The I-frame collision detection service is mainly divided into two steps:

Step1: I-frame information collection

- The video management platform obtains the information of the devices and the analysis result of the data stream and synchronizes it to the MEC for I-frame collision detection.
- The parameter information includes device identification, IP address port, channel number, stream type, I-frame sending start timestamp, I-frame sending completion timestamp, code rate, frame rate, Group of Pictures (GOP) size, etc.

Step2: I-frame collision detection

- Performing time-sharing hash processing on the collected data. It is hashed to the corresponding time slot by the method of time-sharing hashing. If there are multiple devices in the same time slot, it is regarded as I-frame collision.

Table – Example for I-frame timing distribution of three devices

	1			2			3			4			5			6			7			8			9	
IPC-1	I	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
IPC-2	P	P	P	P	I	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	
IPC-3	P	I	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	P	

5G network peak control technology – 3 of 3

Network peak scheduling service

Network peak scheduling refers to calculating the weight of each time slot based on time-sharing hashing after an I-frame collision occurs, adjusting the I-frame timing of the conflicting video device, and forcing its I-frame timing to a time slot with a high idle weight, so as to achieve the collision traffic peak where all front-end video devices are staggered by I-frame in time.

Weight calculation method:

Hash value: $N_0 \sim N_{15}$ (subject to the number of hashes)

Minimum hash value: $N_{min} = \min(N_0 \sim N_{15})$

The left weight of i-th hash: $L_i =$ the number of consecutive N_{min} on the left

The right weight of i-th hash: $R_i =$ the number of consecutive N_{min} on the right

I-th hash weight:

$$X_i = \begin{cases} 0 & != N_{min} \\ \min(L_i, R_i) + 1 \end{cases}$$

Table – Example of I-frame time slot distribution

Device	I-frame timestamp	Hash slot
1	X+120ms	2
2	X+200ms	2
3	X+500ms	5

Slot Hash Distribution	0	2	0	0	1	0	0	0	0	0	0	0	0	0	0	0
Corresponding weight	1	0	1	1	0	1	2	3	4	5	6	6	5	4	3	2

New Hash Distribution	0	1	0	0	1	0	0	0	0	0	1	0	0	0	0	0

Application results – 1 of 2

Taking the effect to be achieved before and after the collision of four devices, the flow staggered effect is shown below.

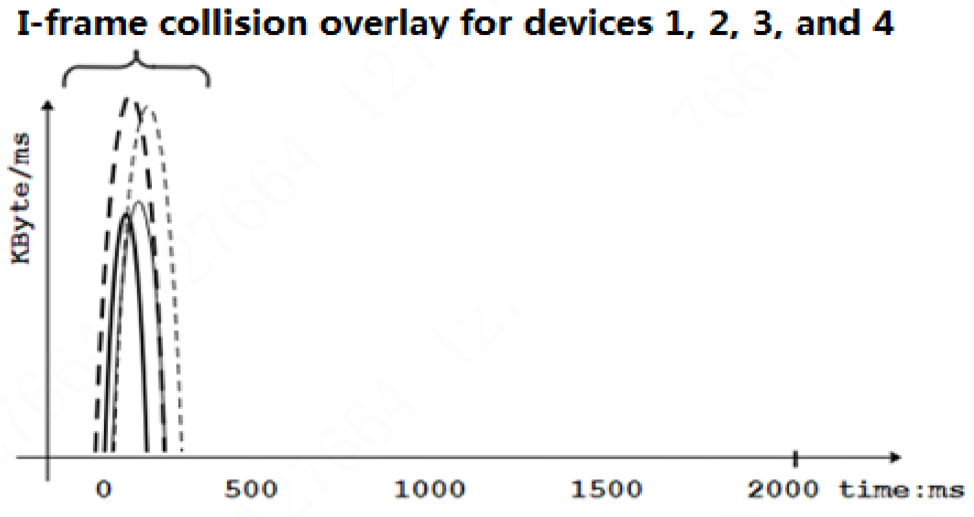

Figure – Four devices collision status before the I-frame is staggered

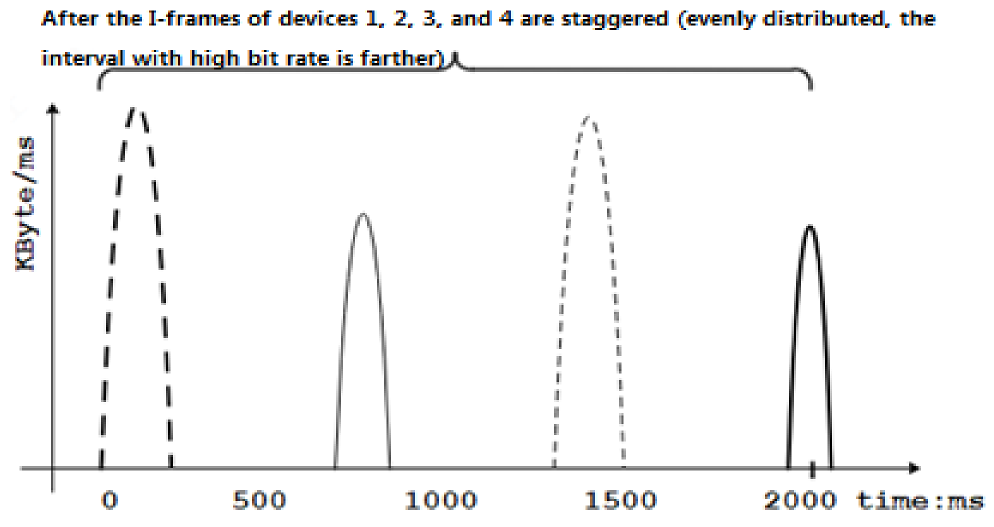

Figure – Four devices collision status after the I-frame is staggered

Application results – 2 of 2

In the case of staggered peaks, the 200ms granularity key frames of N devices are evenly dispersed, and the peak rates of staggered peaks are as follows:

Maximum number of I-frames=floor ((N+9)/10)

*Number of P frames=N*5-Number of I-frames*

*Peak rate at staggered peaks= (number of I-frames * size of I-frames + number of P frames * size of P frames)/200ms*

In extreme cases, the key frames of N devices are burst in the same 200ms, and the peak rate during full collision is as follows:

Maximum number of I-frames=N

*Number of P frames=N*5-Number of I-frames*

*Peak rate at full collision= (number of I-frames * size of I-frames + number of P frames * size of P frames)/200ms*

Table – Compression peak rate at peak staggered and full collision

Number of Device	Peak rate at staggered peaks (Mbps)	Peak rate at full collision (Mbps)	Staggered peak drop (%)
1	11.2	11.2	0.00
4	23.2	44.8	48.2
7	35.2	78.4	55.1
10	47.2	112.0	57.9
13	66.4	145.6	54.4
14	70.4	156.8	55.1
16	78.4	179.2	56.2
30	141.6	336.0	57.9
31	152.8	347.2	56.0

According to the actual measurement, 1080P high-definition real-time video with a bit rate of 4Mbps, the average size of I-frame is 200KB, and the average size of P frame is 20KB.

Conclusion and standardization consideration

With the widespread deployment of 5G networks around the world, 5G applications in various vertical industries have gradually entered the stage of large-scale deployment from pilot demonstrations.

- How to use wireless bandwidth resources more effectively in practical applications is very important in terms of commercial implementation and technical feasibility.
- The severe fluctuation of network peaks in 5G video surveillance scenarios is largely caused by the collision of I-frames during multi-channel video transmission. Network peak control in 5G video transmission scenarios can effectively smooth multiple channels and facilitates the large-scale promotion of 5G video transmission scenarios.
- The current 5G technical standards mainly focus on 5G network capabilities, and there is a lack of technical standards that integrate with industry business characteristics such as video surveillance. To better promote 5G in industry services, it is necessary to deeply study the integration of 5G networks and industry services. The development of standardized technologies combined with business characteristics to achieve 5G networks truly lands in industry applications and network peak control technology for concurrent transmission of multi-channel videos in 5G networks is an important one.

Thank you!