ITU Workshop on
the future of Television
for Asia and Pacific

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Japan Cable Laboratories

RF/IP Adaptive Video Distribution over Cable Television Network

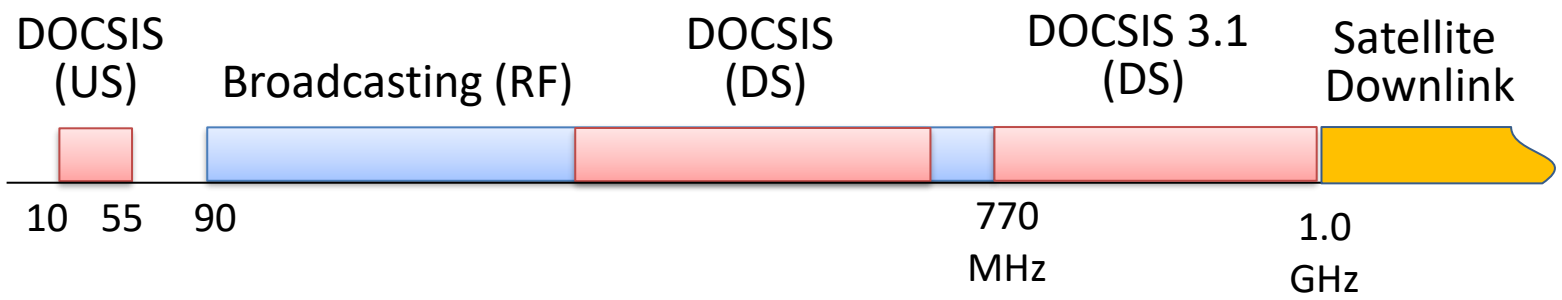
26 April 2021

Japan Cable Laboratories

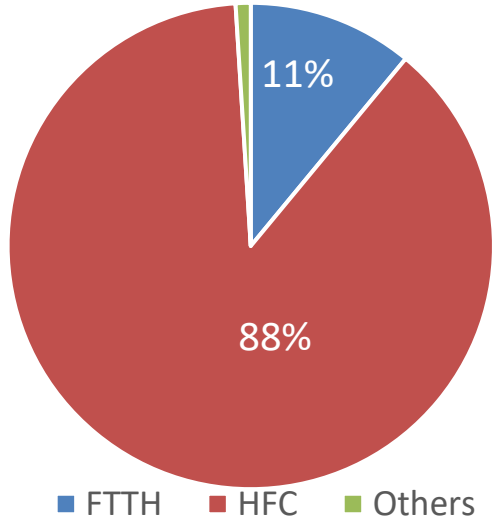
Problem Statement

A novel approach is required to make best use of HFC

- Cable industries seek to increase 4K video channels to respond to the demands from customers.
  - Final goal is to convert 100+ cable channels into 4K.
- HFC band is now fully utilized by existing cable channels and internet services, and can't be expanded beyond 1GHz due to retransmission of satellite broadcasting.
- Furthermore, cable operators cannot easily replace HFC by FTTH because of high cost of FTTH.



Typical utilization of HFC band



Access network type in 2017

RF/IP adaptive distribution scheme is proposed.

Strategy

Create an environment where almost all subscribers can watch 4K videos

Key Idea

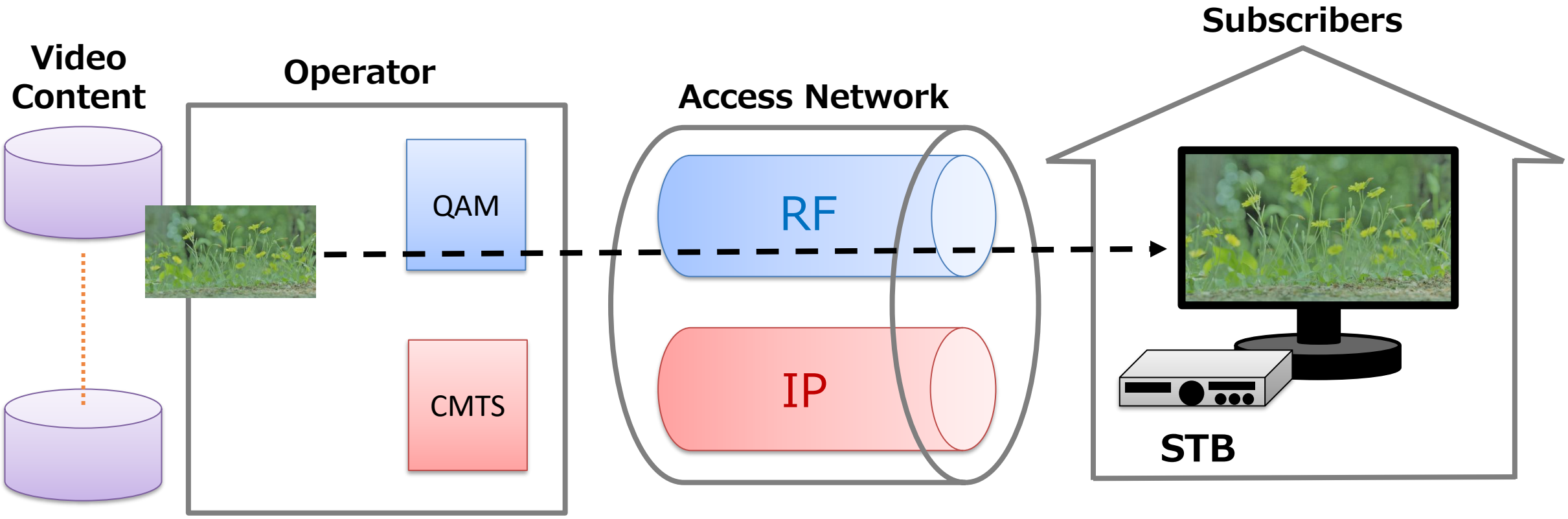
1. Sharing the RF/IP network resources
2. Adaptive control of video qualities & distribution schemes based on three parameters
   - Attribute of video content (e.g. emergency degree)
   - Available network bandwidth
   - Audience rating of each video content or programme/channel

Audience Rating Emergency Degree	High	←				Low
Scheme-Quality	RF-4K	IP-4K	RF-HD	IP-HD	RF-SD	IP-SD
Bitrate (bps)	20M	15M	10M	7M	5M	3M

Priority rule of video quality & distribution schemes

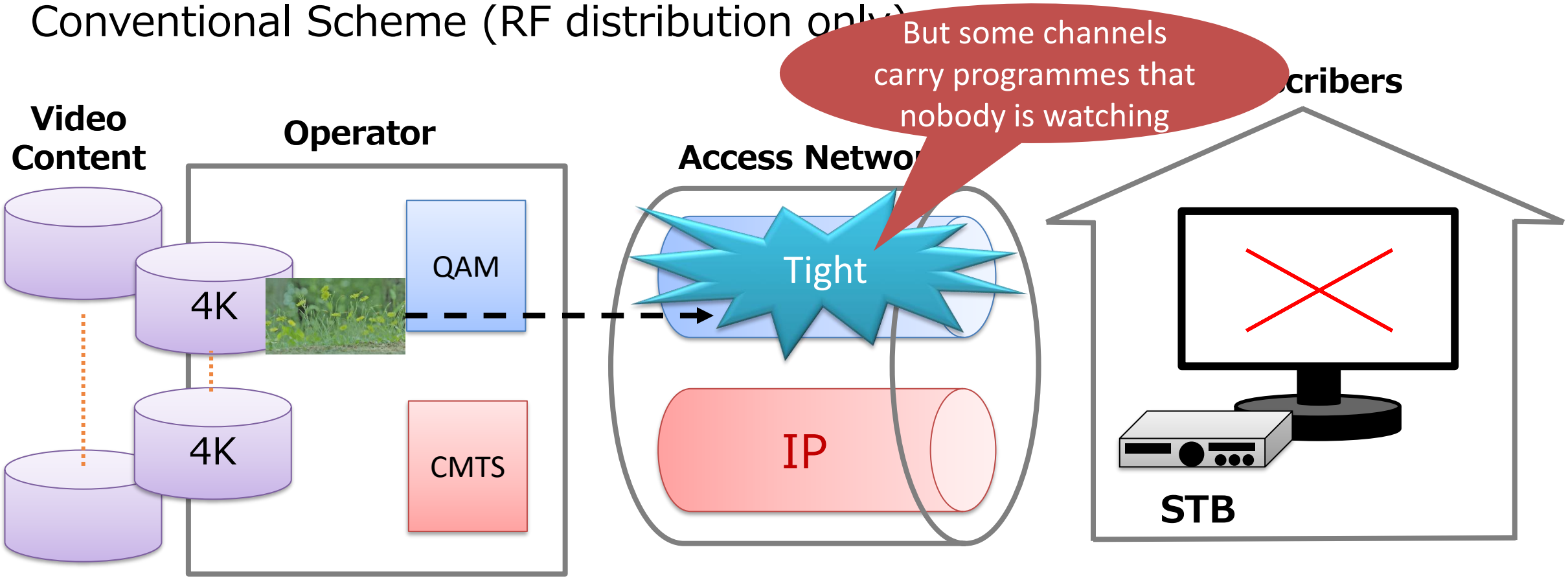
Proposed Method

Conventional Scheme (RF distribution only)



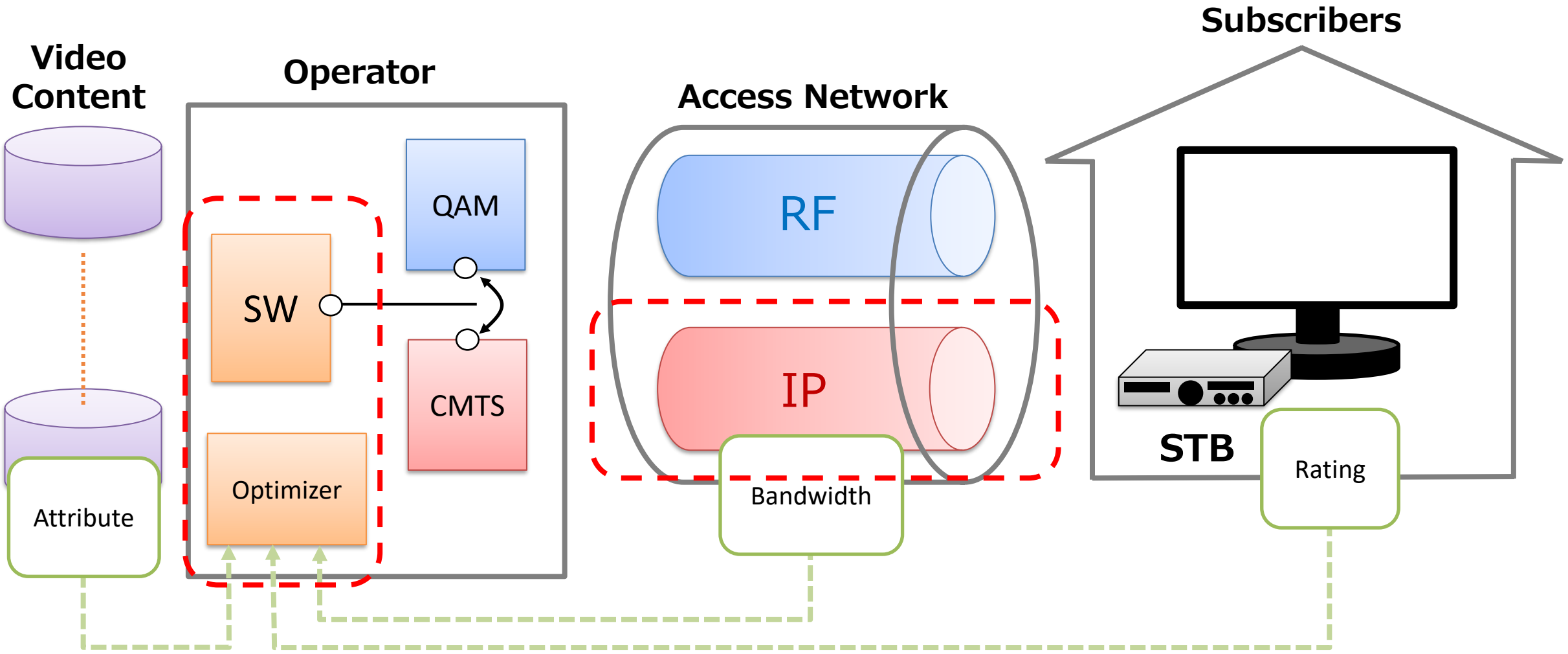
Proposed Method

Conventional Scheme (RF distribution only)



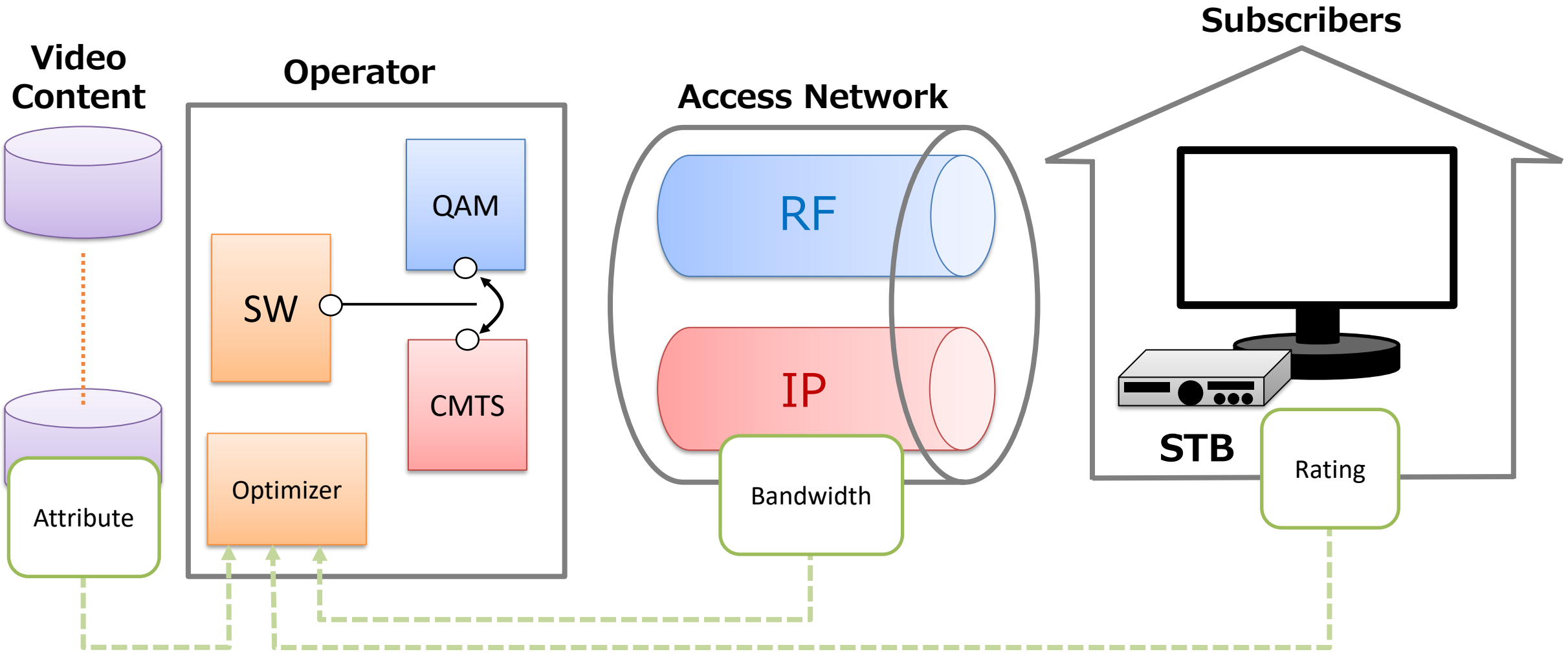
Proposed Method

RF/IP adaptive distribution Scheme



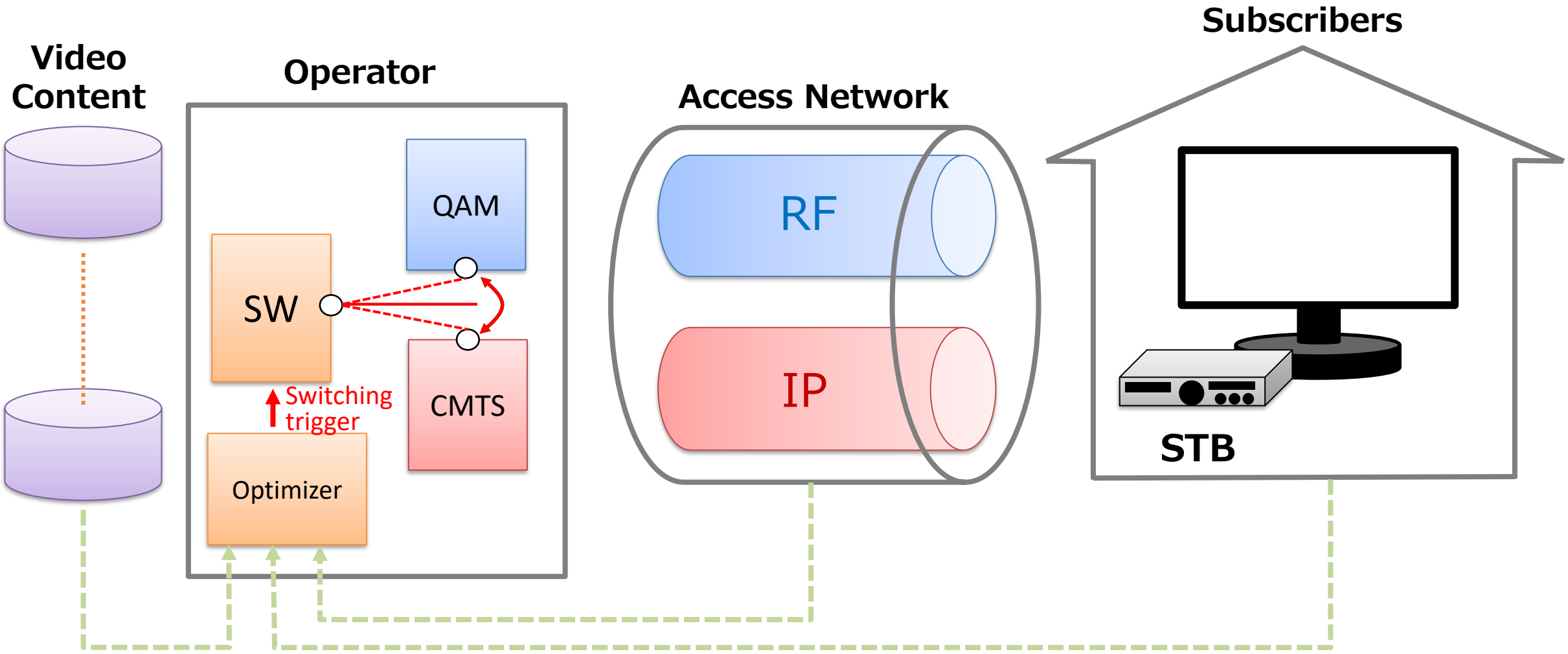
Proposed Method

RF/IP adaptive distribution Scheme



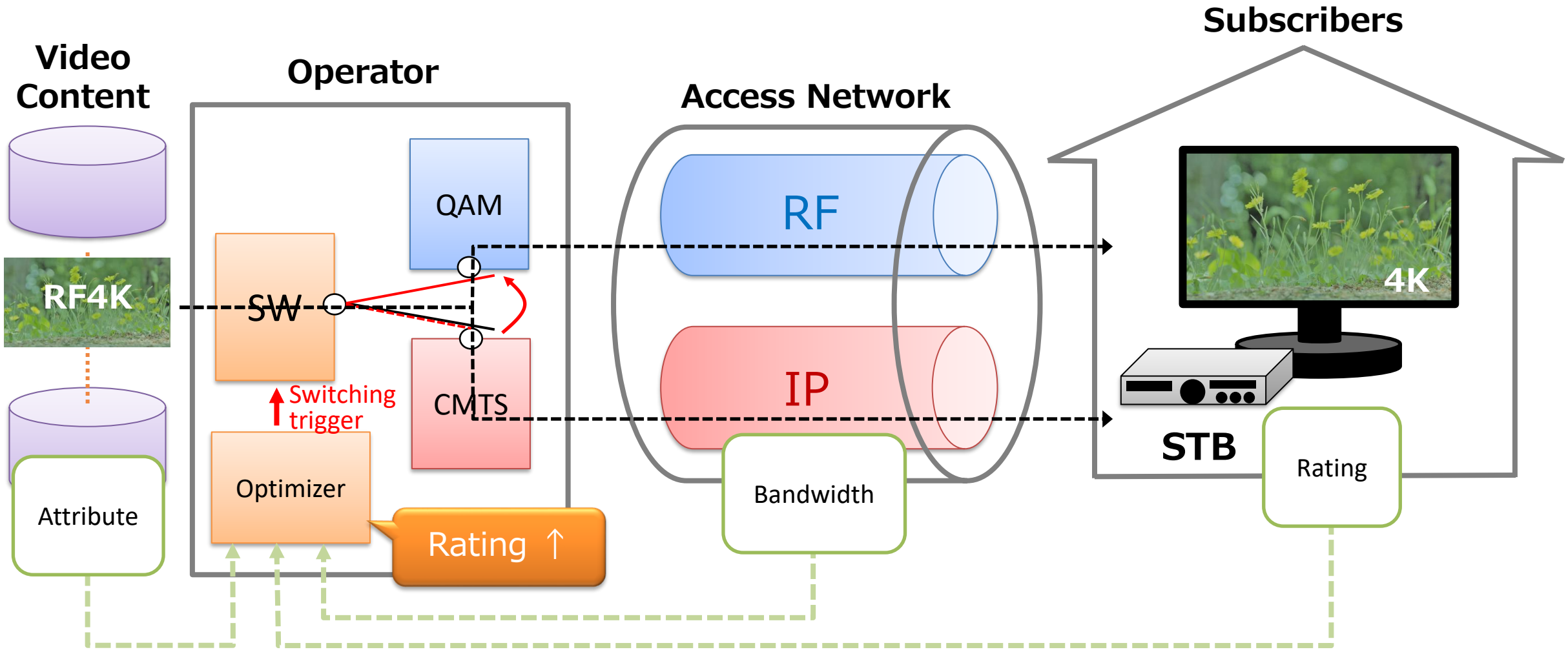
Proposed Method

RF/IP adaptive distribution Scheme



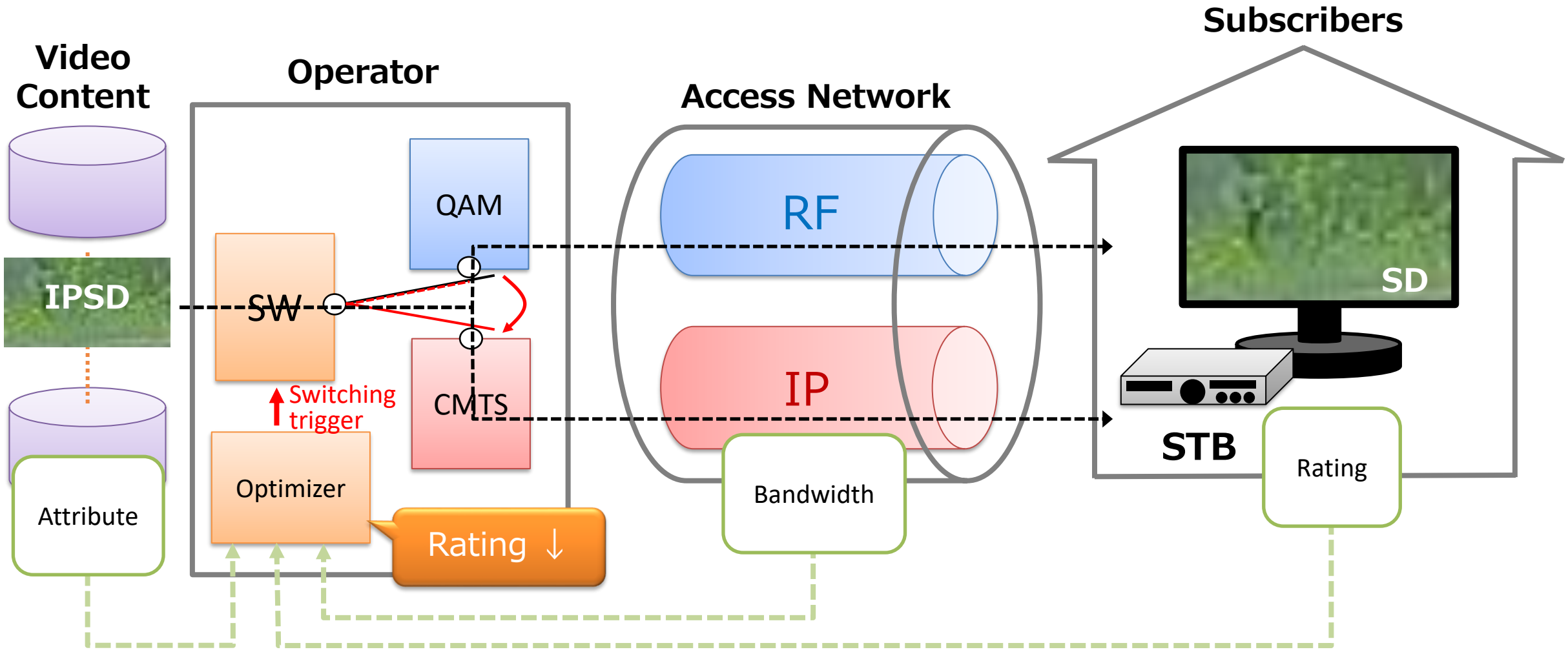
Proposed Method

RF/IP adaptive distribution Scheme



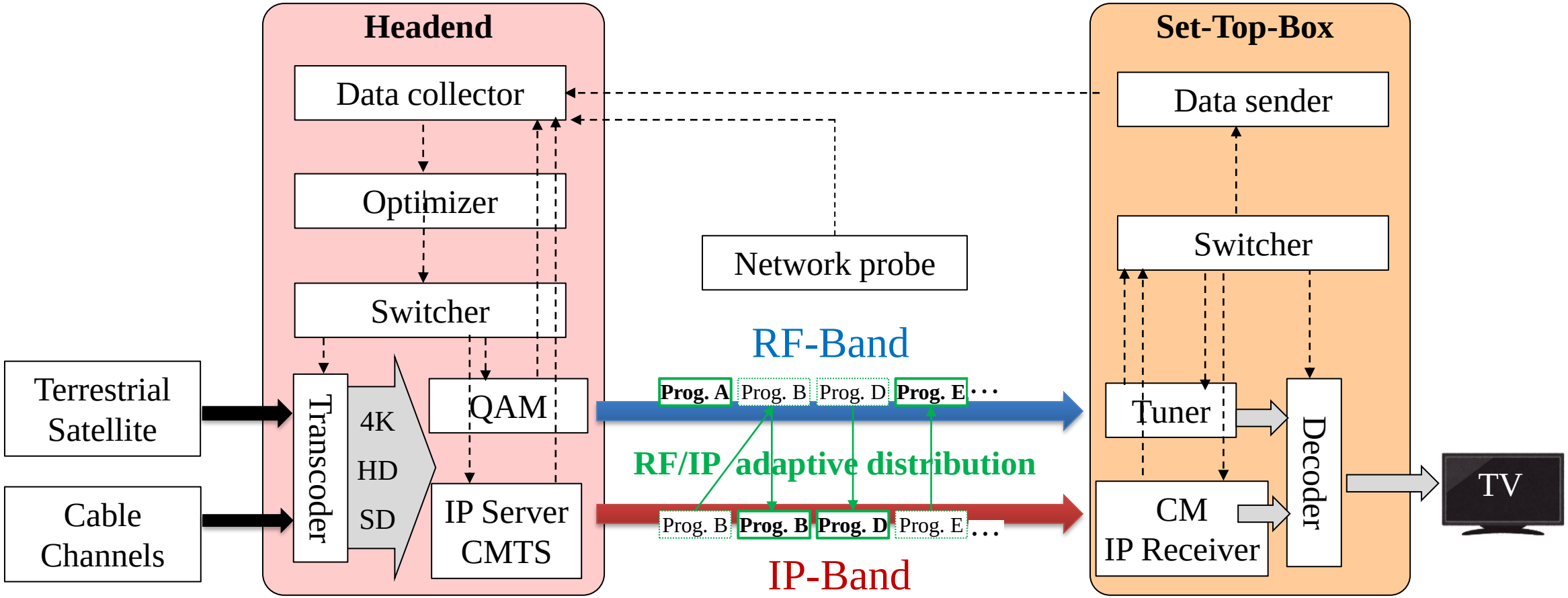
Proposed Method

RF/IP adaptive distribution Scheme



Proposed Method

System Architecture of Proposed Scheme



Key Component/Technology

1. Optimizer / Switching indicator

- **ASD: A**udience **S**atisfaction **D**egree (≒ QoE)
- Definition: Ratio of A and B
  - **A**: Measured score based on actual ratings and actual bitrate
  - **B**: Ideal score based on actual ratings and 4K bitrate

$$ASD(t) = \frac{\mathbf{A}}{\mathbf{B}} = \frac{\sum_{i=1}^{n} R_i(t) \times B_i}{\sum_{i=1}^{n} R_i(t) \times B_{max}} \times 100$$

Scheme-Quality	RF-4K	IP-4K	RF-HD	IP-HD	RF-SD	IP-SD
Bitrate (bps)	25M	15M	10M	7M	5M	3M

$R_i(t)$ =Rating of programme *i* at time *t* *B*= bitrate

Key Component/Technology

2. Optimizer / Switching algorithm

- Design: Recursive assignment of RF/IP channels based on the priority rules
- Processing Order:
  1. Collect the latest data: ratings, bandwidth availability, and attribute of video content
  2. Sort programmes/channels by ratings
  3. Assign programmes with high ratings to the RF at high bitrates (such as 4K).
  4. Change scheme (RF to IP) and quality (bitrate) if bandwidth becomes insufficient
  5. Recurse No.3 and No.4 processes until all programmes are completely assigned.
  6. Calculate difference of new/old ASD based on the new/old assignments
  7. Switch scheme and quality if the difference is greater than a predetermined threshold
- **→ Simulation experiments for validation was conducted.**

Proposed Method

Key Component/Technology

3. Data Collector, etc. / Real-time and large-scale data collection

- Purpose: Guarantee the accuracy of the switching scheme
- Requirement: Lightness, ease to implement
- Preliminary study result: **MQTT* is the best protocol**

*Message Queuing Telemetry Transport

4. Switcher / Seamless switching

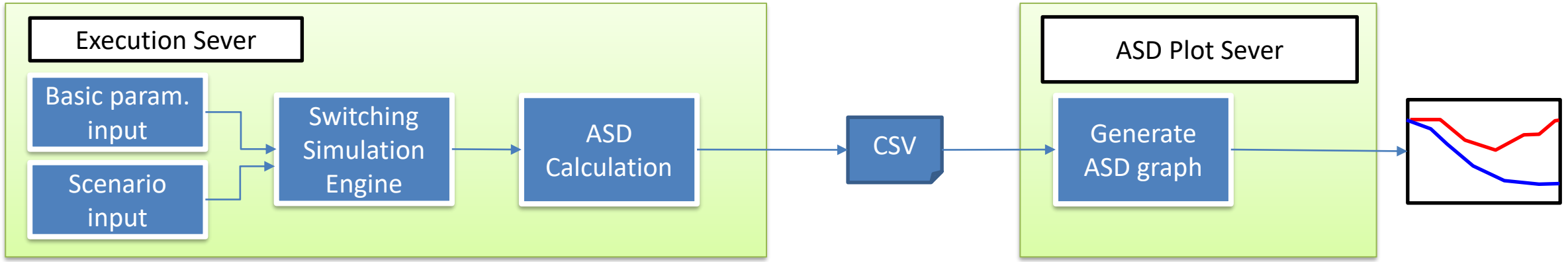
- Purpose: Avoid subjective side-effects from the switching
- Requirement:
  - Method to transmit the switch timing from HE to STB
  - Method to execute the switch without interruption (e.g. frame loss) in video and audio
  - Method to solve the difference in video format (e.g. resolution, frame rate, codec)

→ **Feasibility study thorough prototype development of demo system**

Simulation Experiments assuming Real Cable Network

Simulation Conditions

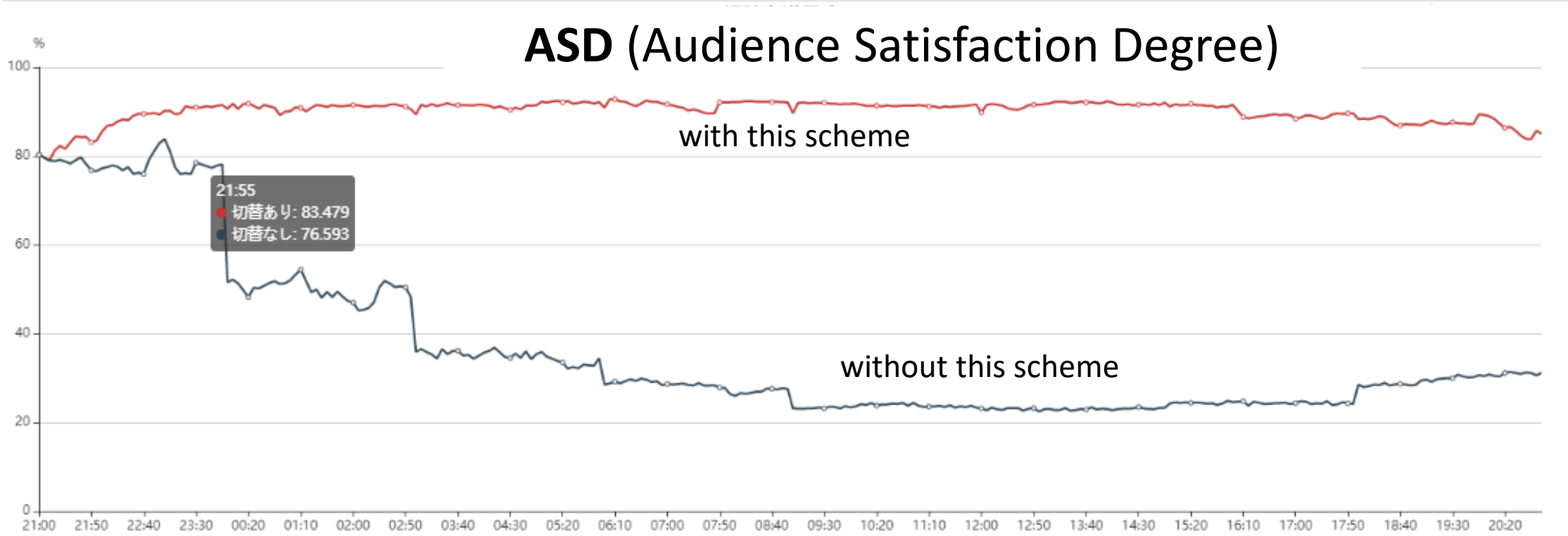
- Basic parameters
  - Number of programmes/channels: 50ch, 75ch, 100ch
  - Network capacity: 8 patterns of RF and IP bandwidth used by Japanese operators
  - Video bitrate: RF-4K: 25M, RF-HD: 15M, RF-SD:6M, IP-SD: 4M
  - Number of STB: 10,000
  - Emulation Time: 24 hours
  - Switching Cycle: 5 min
  - Switching Threshold: 0
- Time-varying parameters
  - Audience rating information from Video Research Ltd., Japan
  - Internet traffic statistics from MIC, Japan (to simulate capacity of IP bandwidth)



Simulation Experiments assuming Real Cable Network

Experiment results

- Num. of programmes/channels: 100ch
- Network capacity:
  - RF-band 900Mbps (= 64QAM x 30ch), IP-band: 320Mbps (=DOCSIS 3.0 x 8ch)



Simulation Experiments assuming Real Cable Network

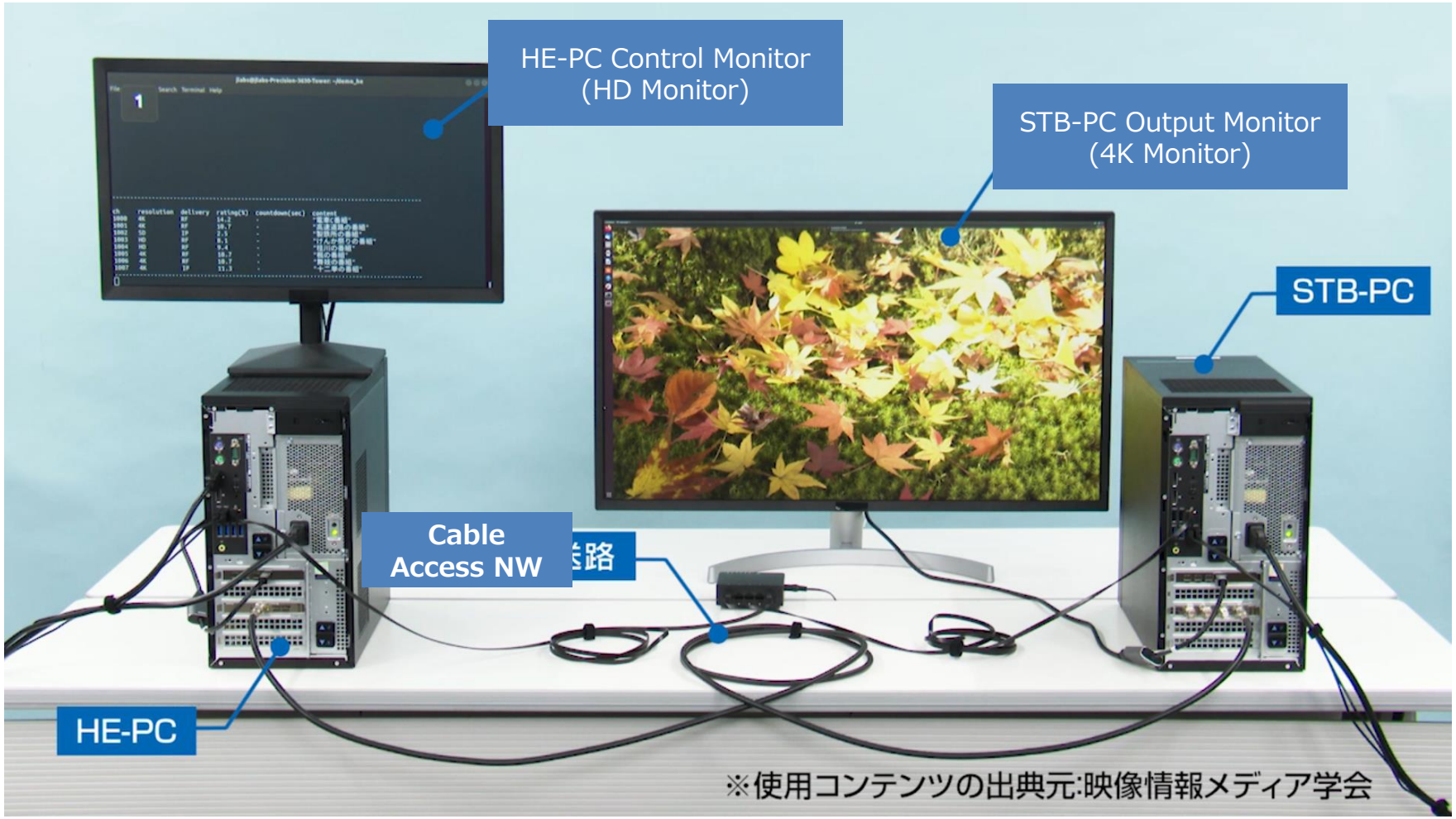
Experiment results under various scenarios

It is observed that ASD with this switching scheme is over double score of ASD without switching.
→ In other words, this scheme can double the number of 4K programmes.

Number of video channel (ch) → ↓ Infrastructure pattern (bps)		50ch = 1250M (if all channels are 4K)	75ch = 1875M (if all channels are 4K)	100ch = 2500M (if all channels are 4K)
1	RF-band: 2070M IP-band : 160M	N/A (Because all channel can be transmitted as 4K)	N/A (Because all channel can be transmitted as 4K)	w/o Switching: 83.7 **w/ Switching: 99.0**
2	RF-band: 1770M IP-band : 160M	N/A (Because all channel can be transmitted as 4K)	w/o Switching: 95.4 **w/ Switching: 99.9**	w/o Switching: 72.3 **w/ Switching: 97.6**
3	RF-band: 1320M IP-band : 160M	N/A (Because all channel can be transmitted as 4K)	w/o Switching: 73.7 **w/ Switching: 97.7**	w/o Switching: 52.7 **w/ Switching: 94.3**
4	RF-band: 1020M IP-band : 160M	w/o Switching: 82.5 **w/ Switching: 98.9**	w/o Switching: 58.6 **w/ Switching: 95.3**	w/o Switching: 40.2 **w/ Switching: 90.5**
5	RF-band: 1950M IP-band : 320M	N/A (Because all channel can be transmitted as 4K)	N/A (Because all channel can be transmitted as 4K)	w/o Switching: 80.2 **w/ Switching: 98.6**
6	RF-band: 1650M IP-band : 320M	N/A (Because all channel can be transmitted as 4K)	w/o Switching: 90.6 **w/ Switching: 99.5**	w/o Switching: 69.7 **w/ Switching: 96.9**
7	RF-band: 1200M IP-band : 320M	w/o Switching: 96.6 **w/ Switching: 99.9**	w/o Switching: 69.9 **w/ Switching: 96.9**	w/o Switching: 49.6 **w/ Switching: 93.4**
8	RF-band: 900M IP-band : 320M	w/o Switching: 78.5 **w/ Switching: 98.2**	w/o Switching: 54.4 **w/ Switching: 94.7**	w/o Switching: 36.5 **w/ Switching: 90.3**

Prototype Development of Switching Demo System

Overview of Demo System



Conclusion and future works

- Highly-efficient video distribution scheme over the existing HFC network is proposed.
  - Basic concepts are the dynamic switching between RF and IP distribution to share the RF/IP resources based on audience ratings, network bandwidth, attribute of video content.

- Theoretical effectiveness and feasibility of the proposed scheme have been confirmed thorough simulation experiments and development of prototype system.
  - Experiment results show that proposed scheme doubles the utilization efficiency of bandwidth or the number of 4K content compared to those without this scheme.
  - Demo system shows the feasibility of seamless RF/IP switching.

- Requirement of the proposed system is now ITU-T Recommendation J. 482 “Requirements of a radio frequency (RF)/Internet protocol (IP) video switching system” (approved March 2021)

- Architecture and functional specification part is now under discussion at SG9, for AAP consent planned in November 2021.

Acknowledgment
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Thank you very much