Proactive Content Caching Utilizing Transportation Systems and its Evaluation by Field Experiment

K. Kanai *et al*., "Proactive content caching utilizing transportation systems and its evaluation by field experiment," *2014 IEEE Global Communications Conference*, Austin, TX, 2014, pp. 1382-1387.

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ICNRG Interim meeting

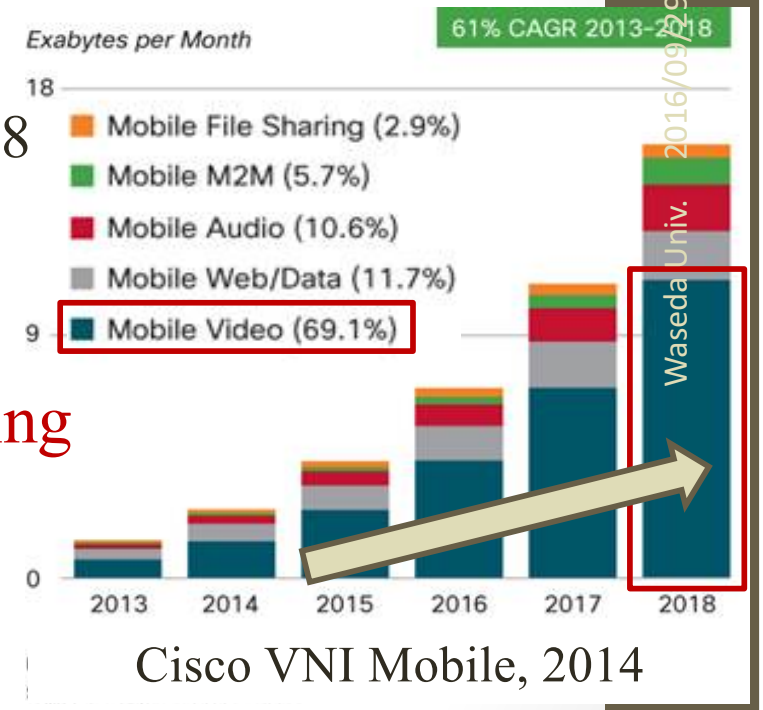
Keping YU * and K. Kanai**
Sato lab.* and Katto Lab.**
GITI, Waseda University and FSE, Waseda University

Outline

- Background
- Proactive content caching scheme
  - Overview
  - Architecture
  - Delivery scheduler
  - Communication protocol
- Evaluation by field experiment
- Results
- Conclusions and future work

Background

- Providing robust video streaming with efficient wireless resource usage is important
  - Explosively increase mobile traffic
  - 70% of them will be mobile video in 2018



Cisco VNI Mobile, 2014

- Proactive content caching scheme utilizing transportation systems
  - High-speed and highly-reliable video streaming
  - Aim to turn a transportation vehicle into a radio communication platform
  - Aim to apply Content Centric Networking architecture

Proactive content caching scheme

Goal

- Provide robust video streaming for mobile users
  - No cellular connection (operator side)
  - No video interruption (user side)

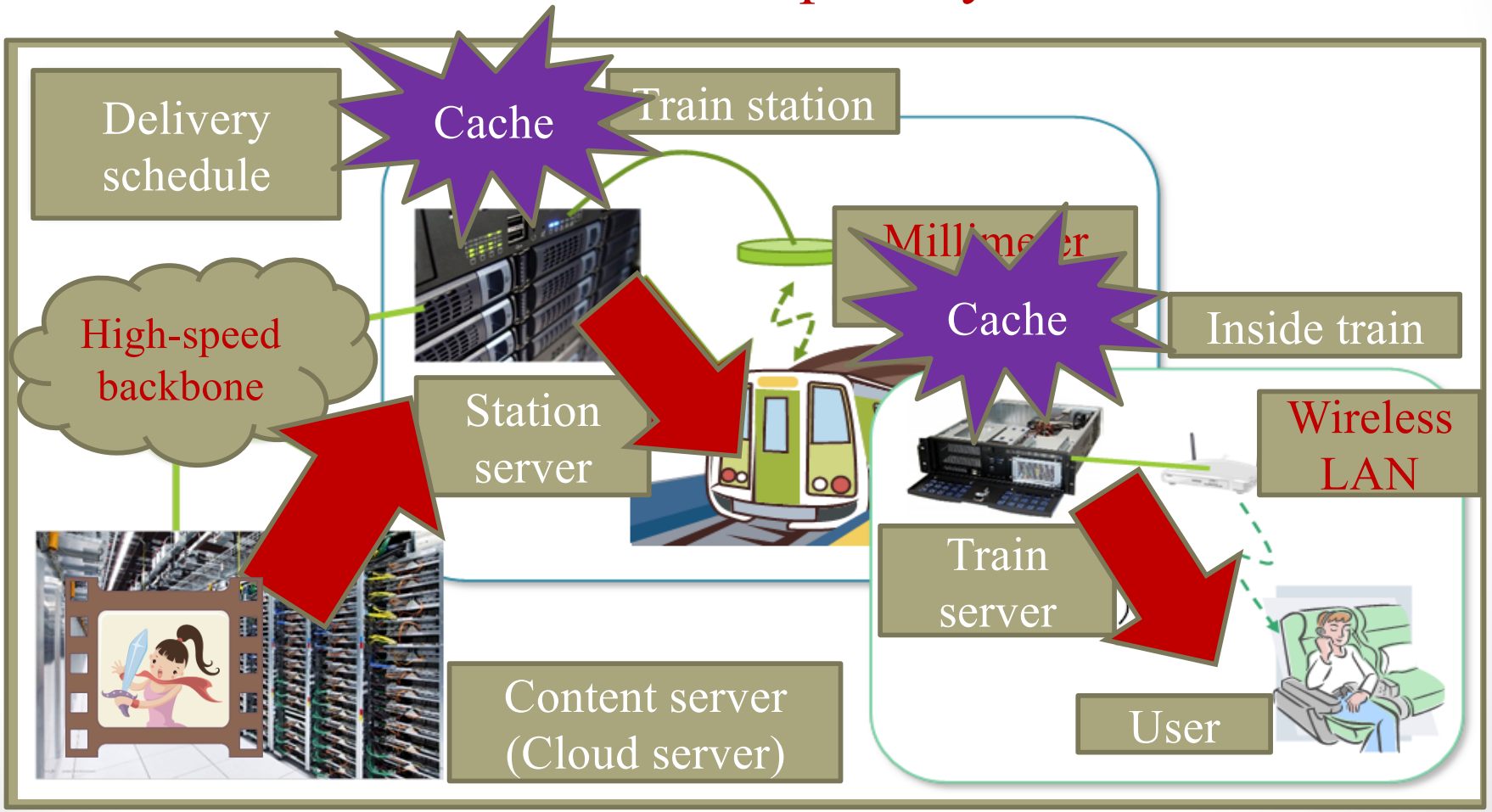
Overview

- Content servers proactively deliver divided contents to some stations
  - According to delivery schedule
- Train receives these distributed contents at the stations
- Train streams these received contents to users

Achieve to reduce delay and packet losses rather than traditional CDN users, especially cellular users.

Proactive content caching scheme ～Architecture～

- Place servers on every train and station
  - Each server has a CCN capability



Proactive content caching scheme ~ Delivery scheduler~

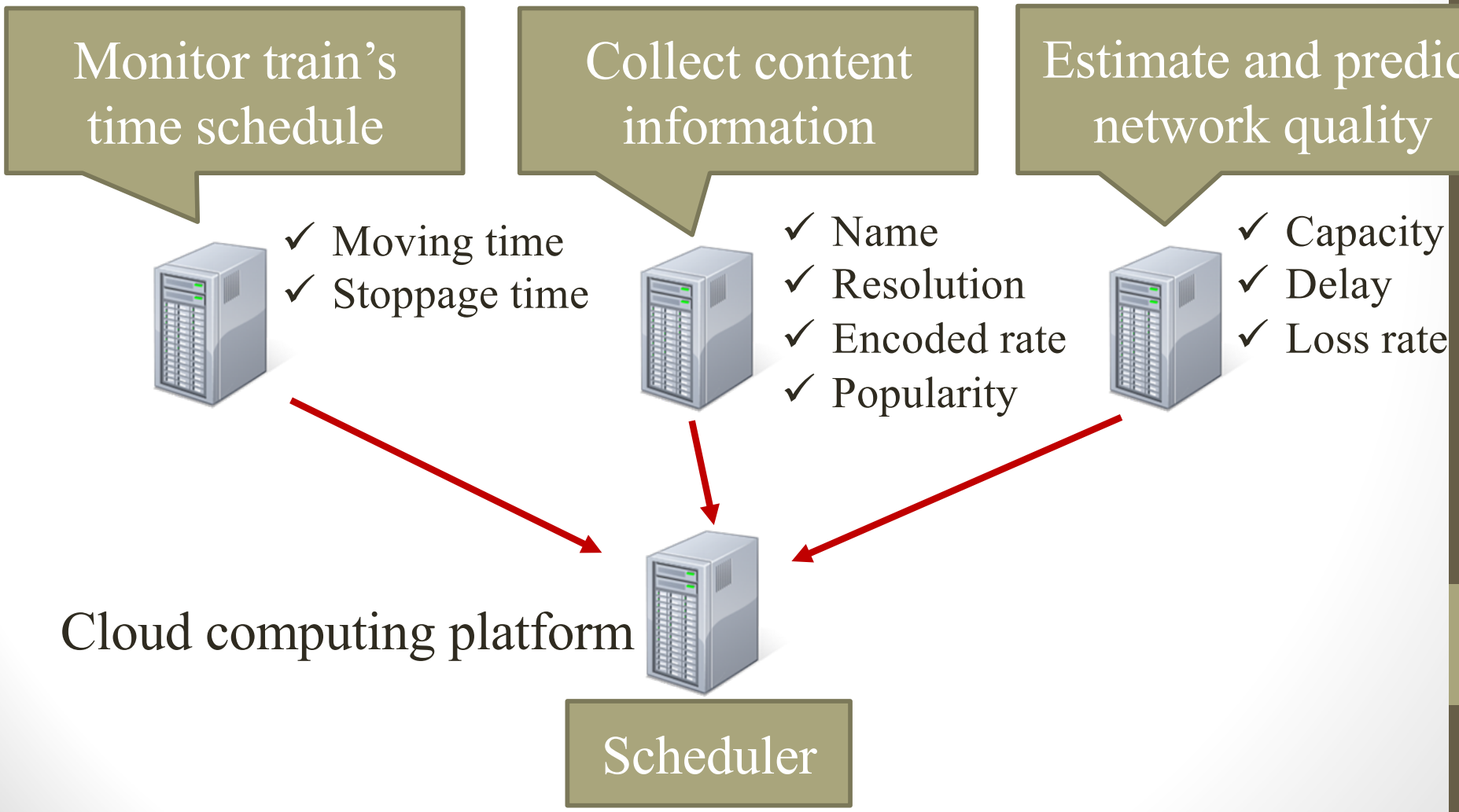
- A key function: delivery scheduler called “smart scheduler”

Three important roles

- Collect latest information
  - Network quality, content information and train’s time schedule
- Define delivery schedule
  - Delivery of what, how many, where and when
- Request contents
  - In case of CCN, create Interest packets to obtain requested contents

Proactive content caching scheme ~ Delivery scheduler~

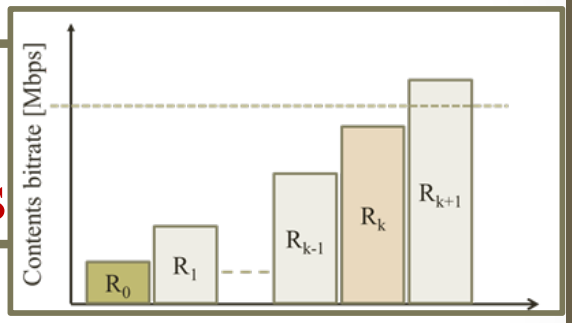
- Collect latest information to define delivery schedule



Proactive content caching scheme ~ Delivery scheduler~

- Define delivery schedule
  - Delivery of what, how ma

MPEG-DASH contents support a hierarchical layer



- What: content quality
- How many: the amount of content segments

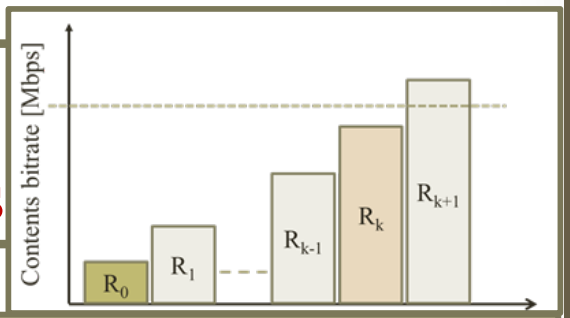
To achieve smooth playback (i.e. no freeze) while moving, content quality and the amount of segments should be controlled adaptively

- Where: Delivery locations
- When: Delivery timing

Proactive content caching scheme ~ Delivery scheduler~

- Define delivery schedule
  - Delivery of what, how ma

MPEG-DASH contents support a hierarchical layer



- What: content quality
- How many: the amount of content segments

These parameters could be calculated by referring the train's time schedule, content information and estimated network quality.

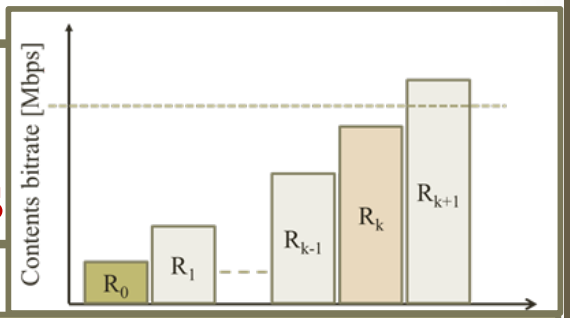
- Where: Delivery locations
- When: Delivery timing

To achieve smooth playback (i.e. no freeze) while moving, content should be delivered proactively before the train arrives at a station

Proactive content caching scheme ~ Delivery scheduler~

- Define delivery schedule
  - Delivery of what, how ma

MPEG-DASH contents support a hierarchical layer



- What: content quality
- How many: the amount of content segments

These parameters could be calculated by referring the train's time schedule, content information and estimated network quality.

- Where: Delivery locations
- When: Delivery timing

These parameters could be defined by referring the train's current location and time schedule.

Proactive content caching scheme ~Optimal content quality~

- Calculate an optimal content bitrate

Delivery timing

✓Proactive caching $S_n \leq B_n * (t_n - t_{n-\alpha_n})$

✓Continuous playback $\frac{S_n}{j_n} \geq R_n * (t_{n+1} - t_n)$

Traveling time to the next station

✓Smooth playback $\frac{D_n}{j_n} \geq R_n$

Optimal content bitrate should be calculated by fulfilling these formulas

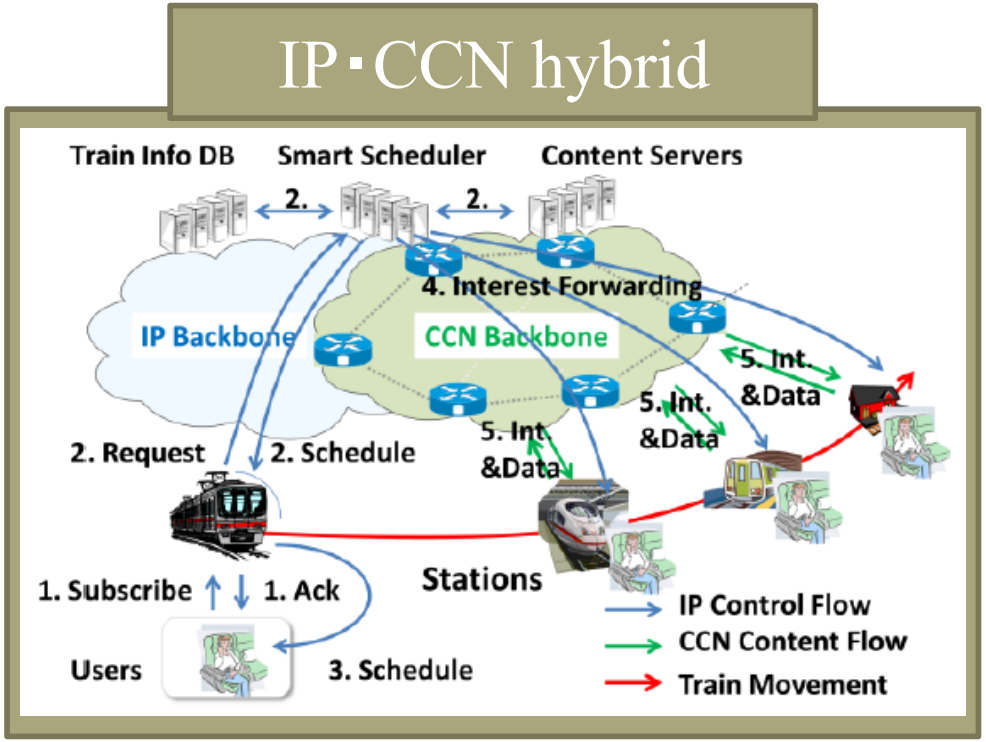
※Transmission data: $S_n = C_n * \Delta t_n$

※Bandwidth could be shared fairly among multiple users

B, C, D: Estimated bandwidth for each access network, j: number of users
α: Delivery timing

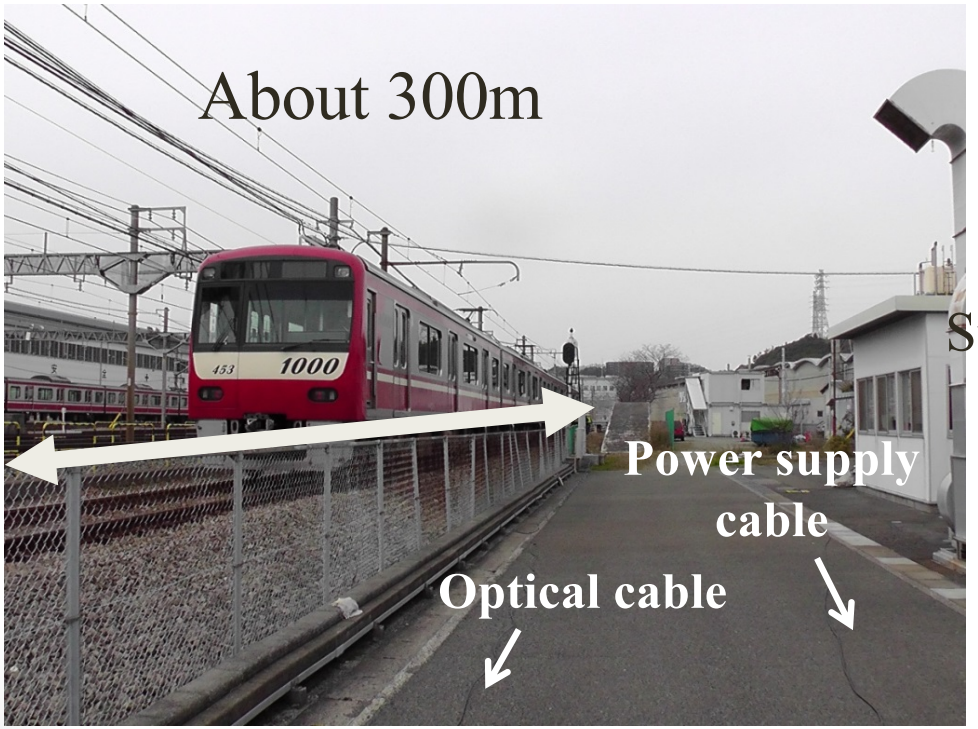
Proactive content caching scheme
～Communication protocol～

Protocol	Control	Content
IP･CCN hybrid	IP	CCN



Field experiment ~Environment~

- We carried out field experiment by using actual trains



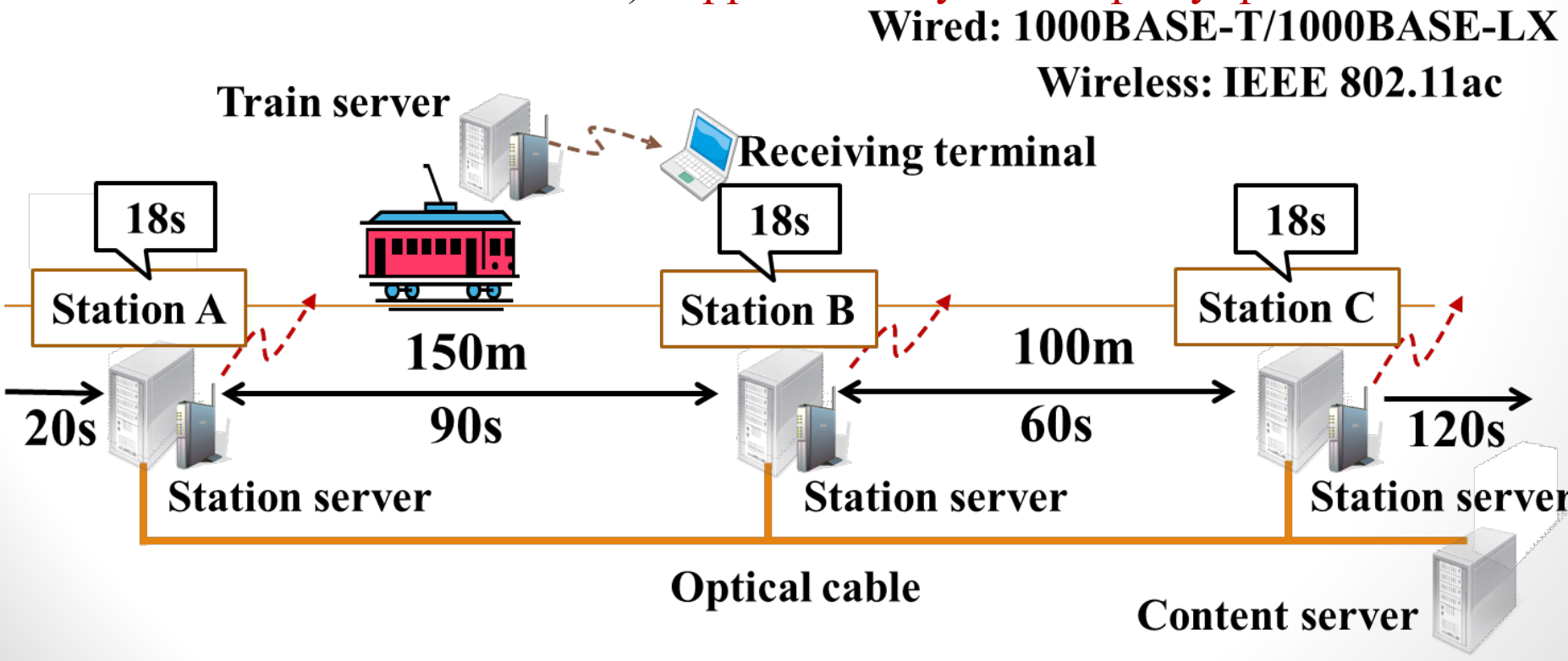
Station A

Station B

Station C

Field experiment
~Evaluation scenario~

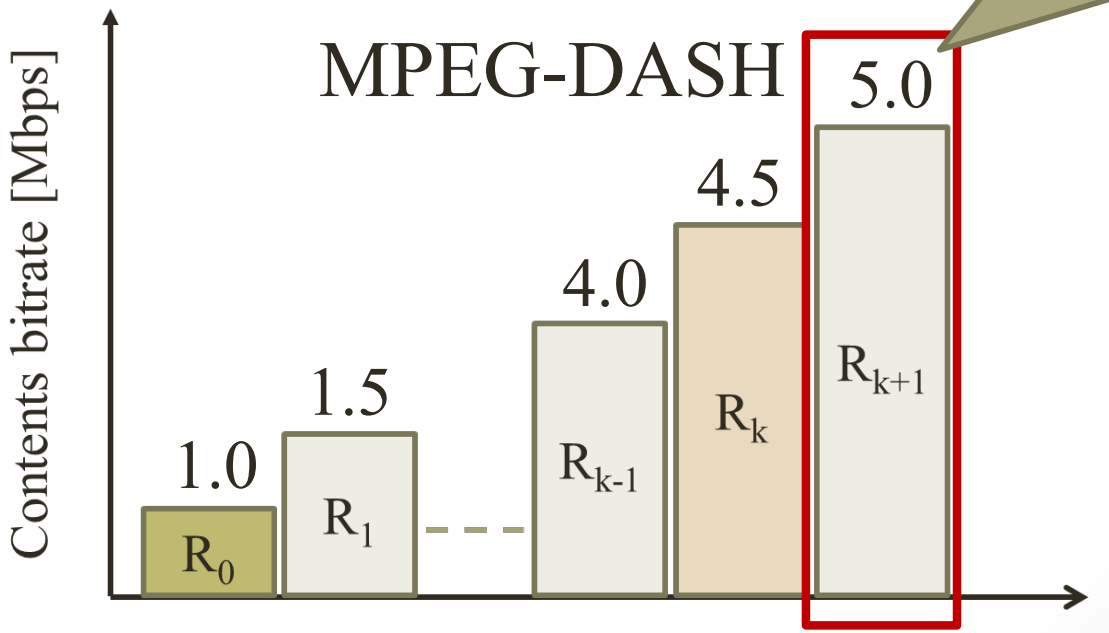
- In this time, we evaluate only a single user case for simplicity
- Train moves from station A to station C according to actual train's time schedule
  - Wired LAN（optical cable）: Approximately 600Mbps by iperf
  - Wireless LAN（802.11ac）: Approximately 100Mbps by iperf



Field experiment
~Evaluation scenario~

- DASH contents
  - Resolution : 1080p
  - Encoder : H.264/AVC
  - Encoded bitrate : 1~5
  - Segment length : 2 sec

In single user case, content bitrate is selected 5Mbps because network bandwidth is so wide.



Field experiment
~Evaluation scenario~

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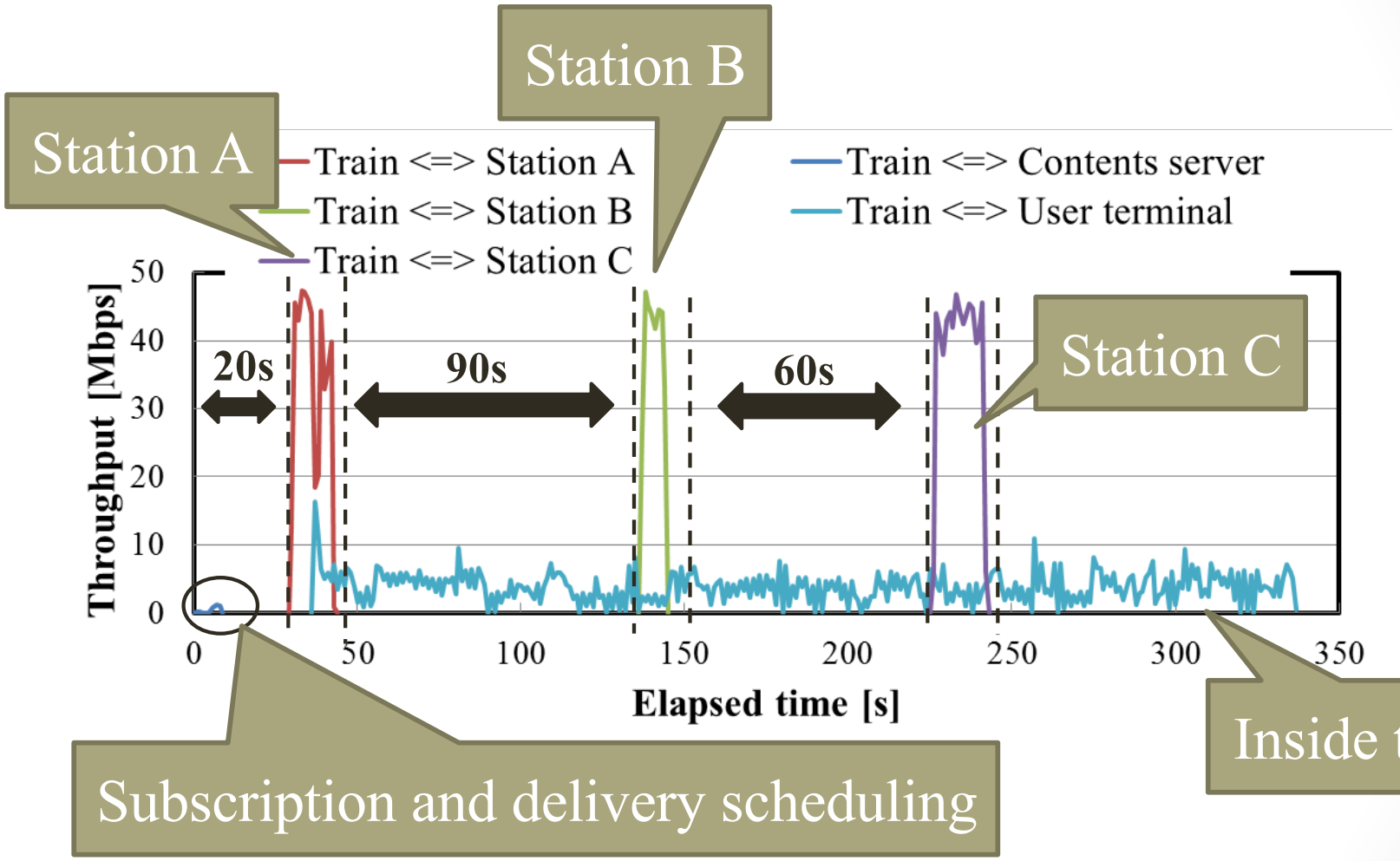
Results



- Requested contents can be completely downloaded while the train stop at the stations
- Achieve to smooth playback without any video freeze

Proactive content caching vs. cellular scenarios

- Cellular scenarios: video streaming via LTE
  - Two user behaviors: still and moving

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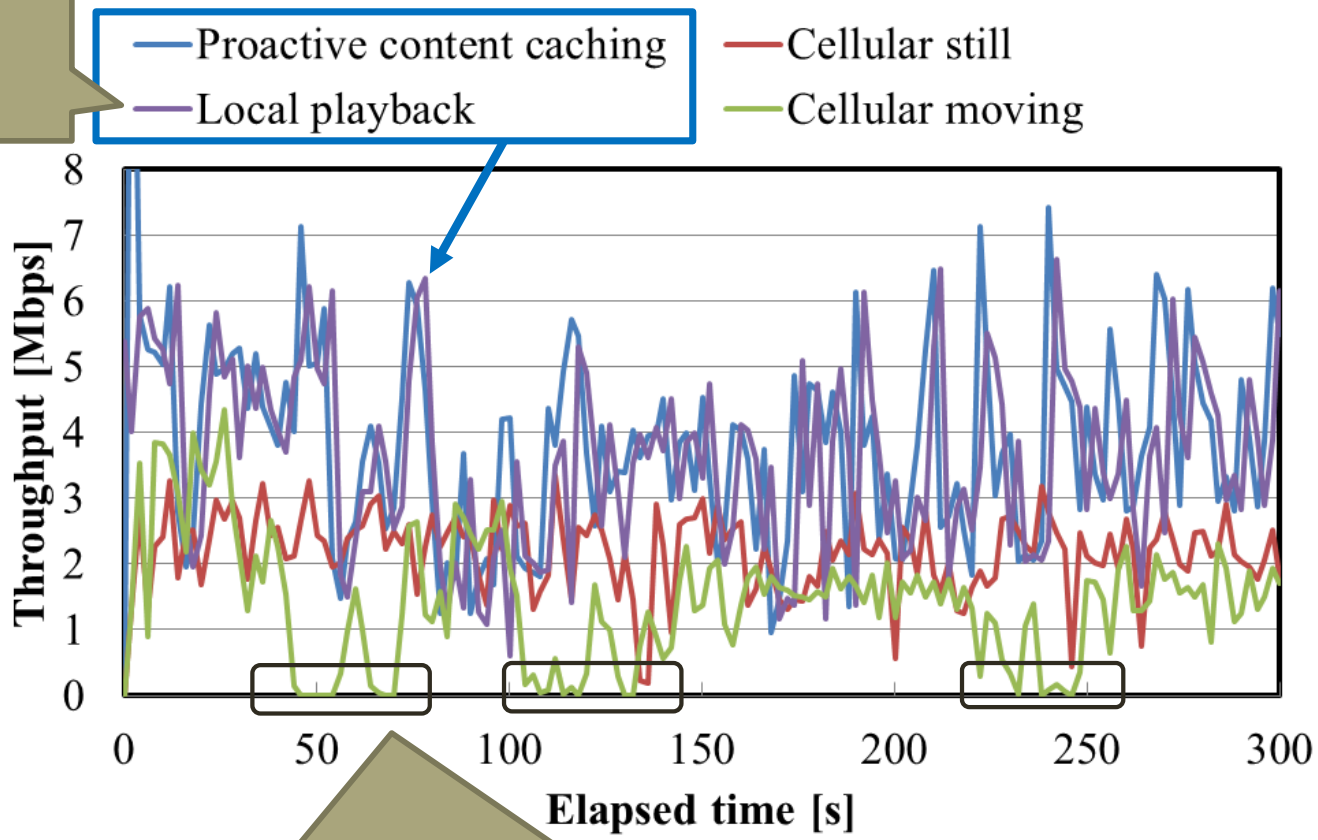
Proactive content caching vs. cellular scenarios

- Cellular scenarios: video streaming via LTE
  - Two user behaviors: still and moving

Similar quality



Video was freeze (cellular scenario)

Conclusions and future work

- Propose proactive content caching scheme utilizing trains
  - Efficient wireless resource usage (operator side)
  - Smooth playback (user side)
- Evaluate and validate its performance by field experiment
- Achieve to experience high-reliable video streaming

In the future

- Modify and evaluate larger-scale scenarios
  - Multiple users and multiple contents
  - Green video streaming
- Extension to automobiles and pedestrians

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