Japan-EU Joint Research: GreenICN, and Proactive Content Caching and Delivery Scheme Utilizing Transportation Systems

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Outline

- GreenICN Overview
- Proactive Content Caching and Delivery Scheme in Public Transportation Systems

GreenICN: Architecture and Applications of Green Information Centric Networking

Green ICN

GreenICN Project

- GreenICN is a project funded by both European Commission and Japanese government.
- The objective is to design a network and end-devices able to operate in a highly scalable, energy-efficient and backward compatible way while exploiting advantages of ICN.
- 3 year project started in April 2014.
- 6 European and 6 Japanese partners collaborate in the project.
- Website: http://www.greenicn.org/
- The GreenICN Network layer is an enhanced NDN module where we add additional functionality and improve existing solutions.

Project Partners

European Partners

GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

EU Coordinator
George-August-Universität Göttingen (Germany)

NEC Europe Ltd. (UK)

CEDEO (Italy)

Telekomunikacja Polska (Orange Labs, Poland)

University College London (UK)

Consorzio Nazionale Interuniversitario per le Telecomunicazioni (Italy)

Japanese Partners

JP Coordinator
KDDI R&D Laboratories Inc. (Saitama)

NEC Corporation (Tokyo)

Panasonic Advanced Technology Development Co., Ltd. (Osaka)

東京大学 THE UNIVERSITY OF TOKYO
University of Tokyo (Tokyo)

早稲田大学 WASEDA University
Waseda University (Tokyo)

大阪大学 OSAKA UNIVERSITY
Osaka University (Osaka)

Objectives

- GreenICN addresses how the ICN network and devices can operate in a highly scalable and energy-efficient way.
- Two exemplary application scenarios:
  1. Aftermath of a disaster:
     - Energy and communication resources are at a premium.
     - Efficient distribution of disaster notification and rescue information is critical.
     - Key issue: Ability to exploit fragmented networks with only intermittent connectivity.
  2. Video delivery:
     - Video consumes large part of current network bandwidth.
     - Efficient delivery of video is crucial to have successful deployment of ICN networks.
     - Key issue: Scalable and efficient video delivery exploiting features of ICN such as in-network caching and name-based forwarding while saving energy consumption.

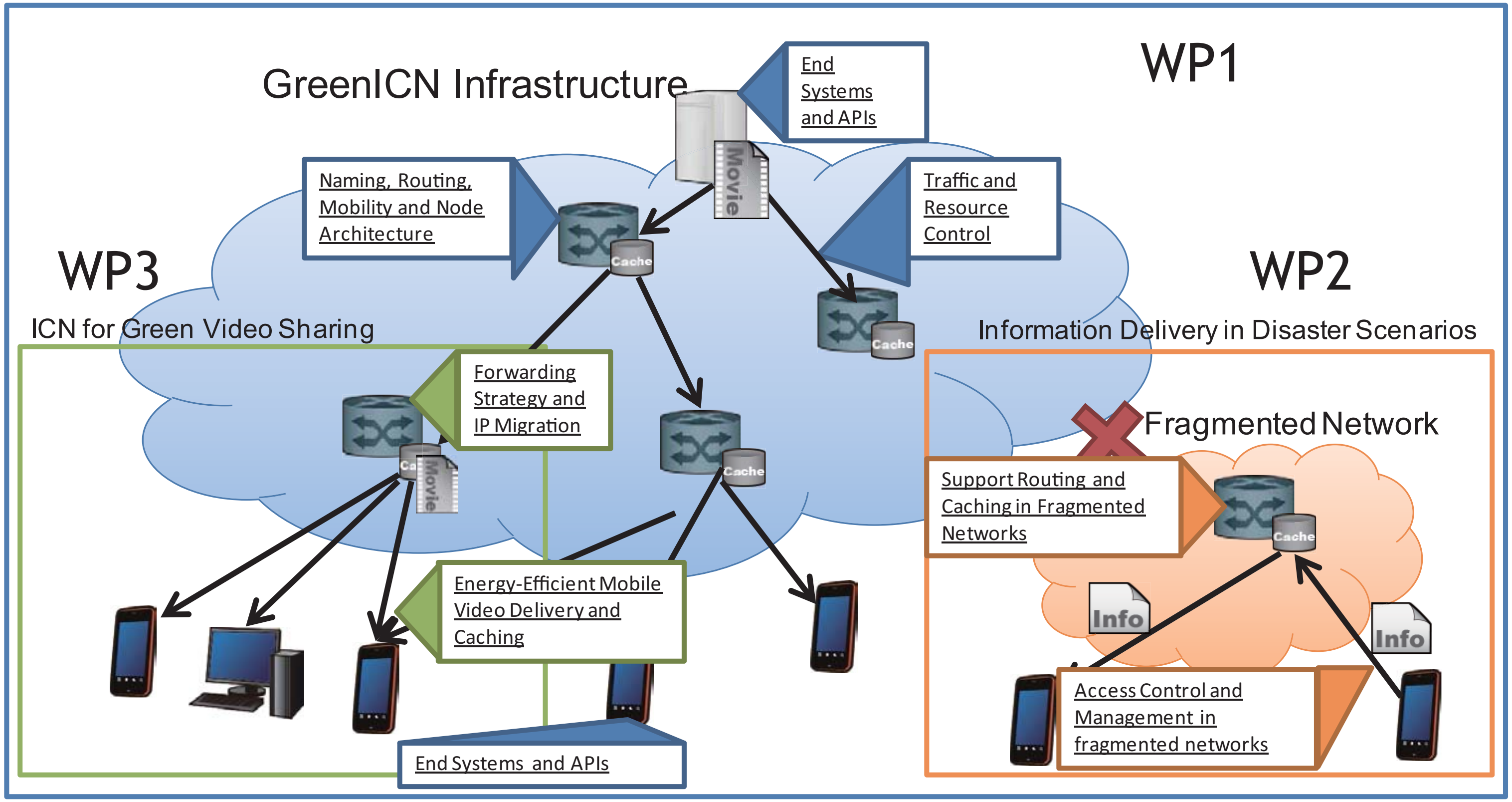
Project Goals

- Reduction of power consumption
  - 20% for normal days
    - EU aims to reduce 20% of the total energy consumption of all EU countries.
    - Japan aims reduce energy consumption 30% by 2030, compared to that in 2003.
  - 40% for Disasters
    - In 2011, people in Tohoku area suffered 3 days of blackout because of the East Japan Earthquake.
    - Reduction to make communication services and related base stations able to operate 3 days in such a scenario.

Project Goals (cont'd)

- Seamless services before and after a disaster
  - From 2011 East Japan Earthquake: people want to keep on using terminals and services they are accustomed to and not those specifically designed for disasters.
- Migration path
  - Friendly coexistence of GreenICN with current IP network
- Scalability
  - Appropriate performance to be usable in the real world.
- ICN-enabled end-systems and a new API
  - A middleware platform provides functionality too complex to be implemented at line-speed in the network layer, allowing end-devices to fully exploit ICN potentials.

Project Structure



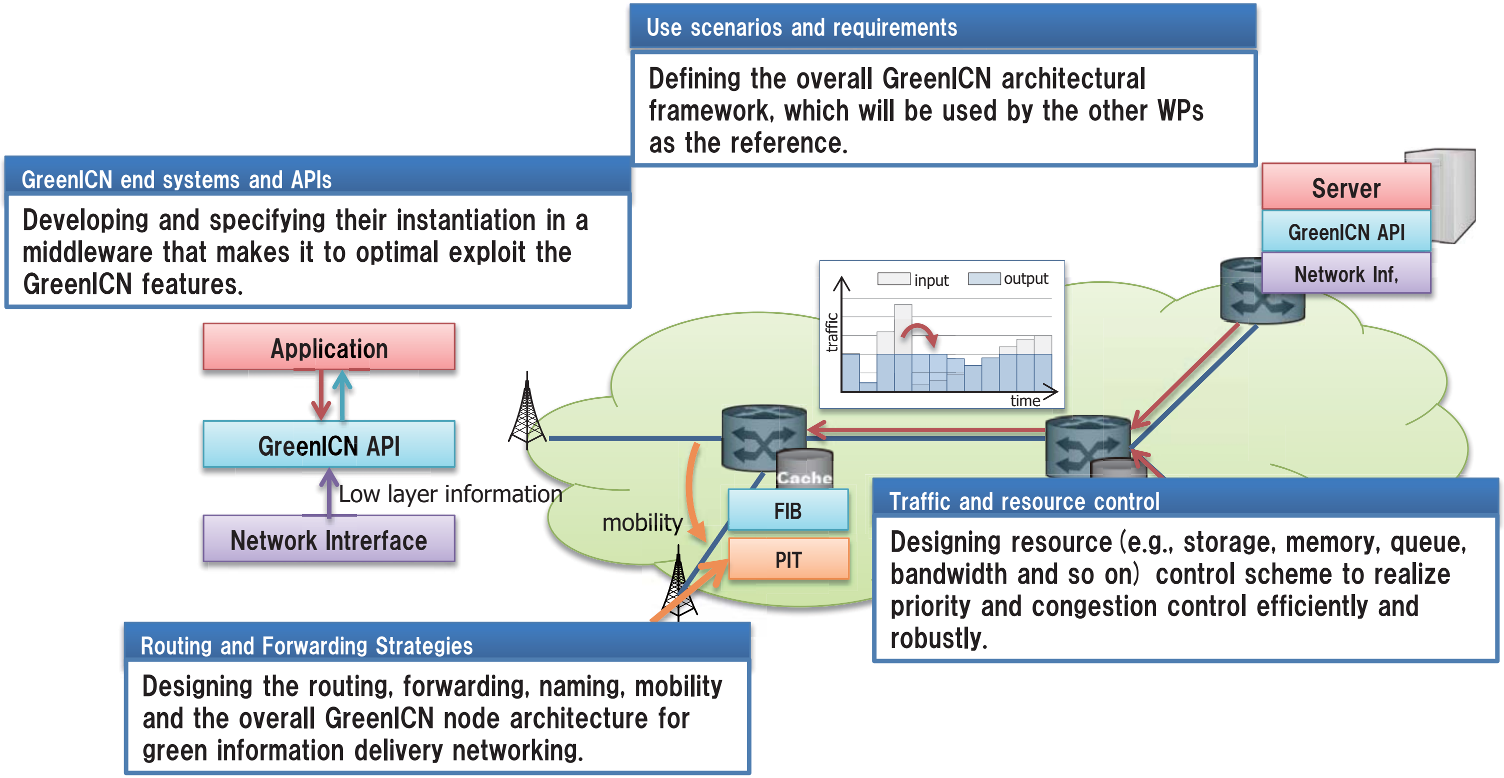
GreenICN Work Packages

WP	Title
0	Project Management
1	Requirements and Architecture for Green Information Delivery Network
2	Green Disaster Information Delivery and Rescue Management
3	Green Video Sharing
4	Prototype Implementation and Evaluation
5	Dissemination, Standardizations and Exploitation

GreenICN

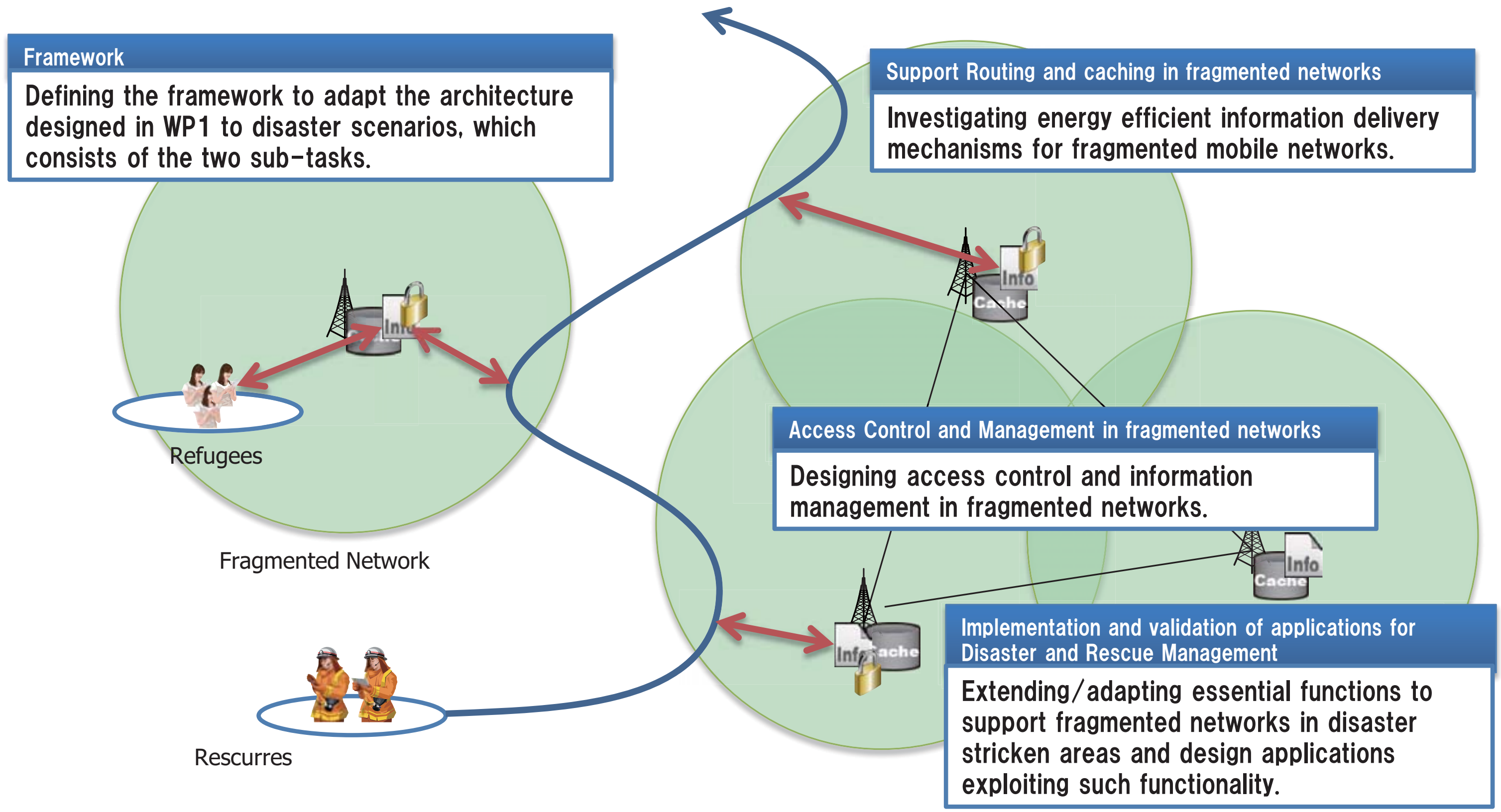
WP1: Requirements and Architecture for Green Information Delivery Network

Goal: Identifying use scenarios and requirements and define the GreenICN architecture.



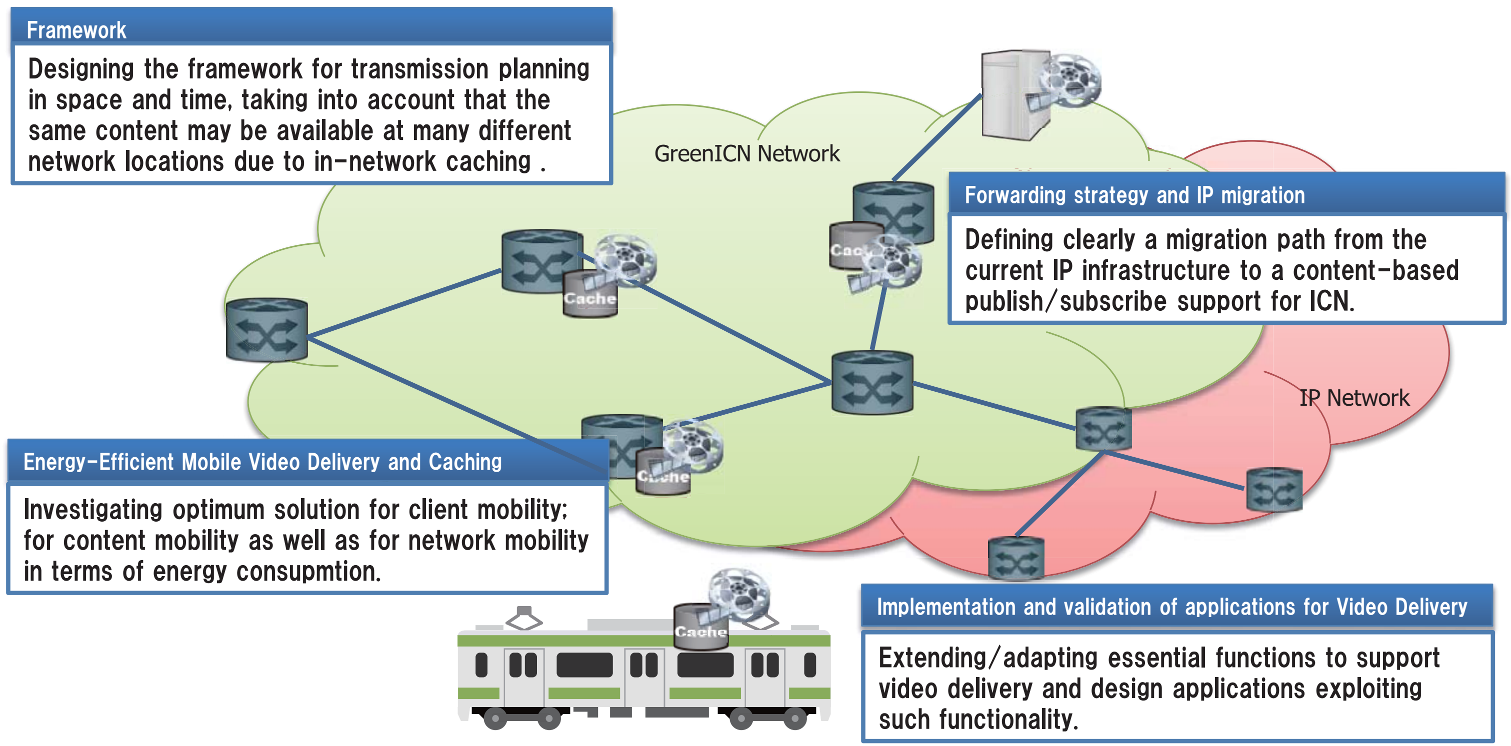
WP2: Green Disaster Information Delivery and Rescue Management

Goal: Support for large-scale energy-efficient disaster information delivery for fragmented/disrupted mobile networks.



WP3: Green Video Sharing

Goal: A framework for collaboration and sharing in order to achieve energy-efficient video delivery.



WP4: Prototype Implementation and Evaluation

Goals:

- Implementation and validation of device-side ICN and middleware functionality
- Implementation and validation of network-side ICN functionality
- Implementation and validation of applications for Disaster and Rescue Management.
- Implementation and validation of applications for Video Delivery

WP5: Dissemination, Standardizations and Exploitation

Goals:

- Dissemination: Spreading the developed technology to research community.
- Standardization: Making the developed technology international standards.
- Exploitation: Making products out of the developed technology.

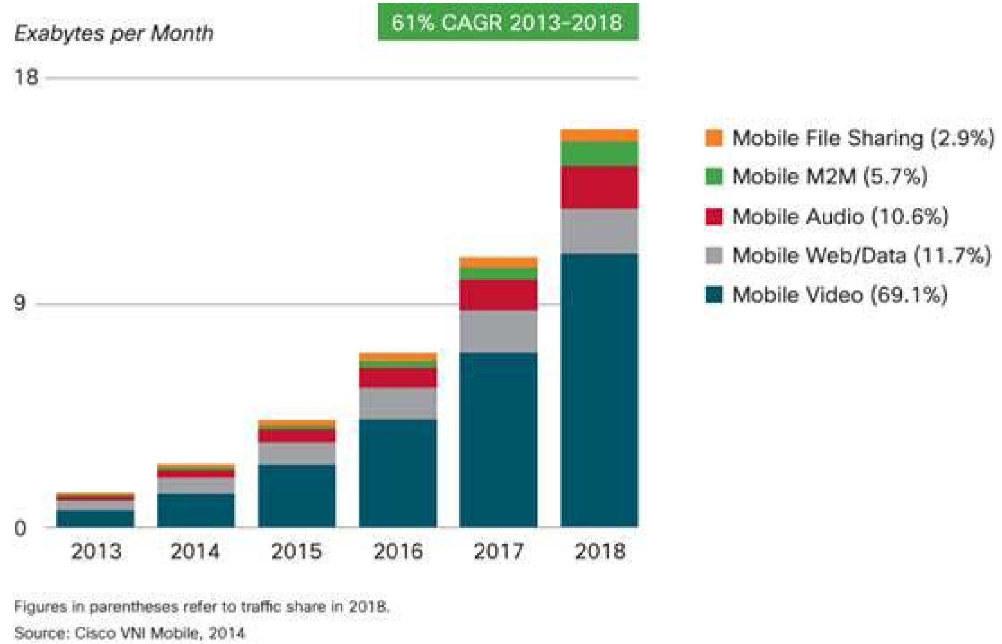
Current Status

- Plenary meetings:
  - Kick-off in Heidelberg: 13-15 May 2013.
  - Tokyo: 11-13 November 2013.
  - Brussels (including official review): 13-16 May 2014.
- Deliverables:
  - 14 internal documents were completed.
- Liaisons with other groups:
  - MPEG
  - IRTF ICNRG
  - ITU-T Focus Group on Disaster Relief Systems, Network Resilience and Recovery

Proactive Video Content Caching and Delivery in Public Transportation Systems

Motivation and Objective

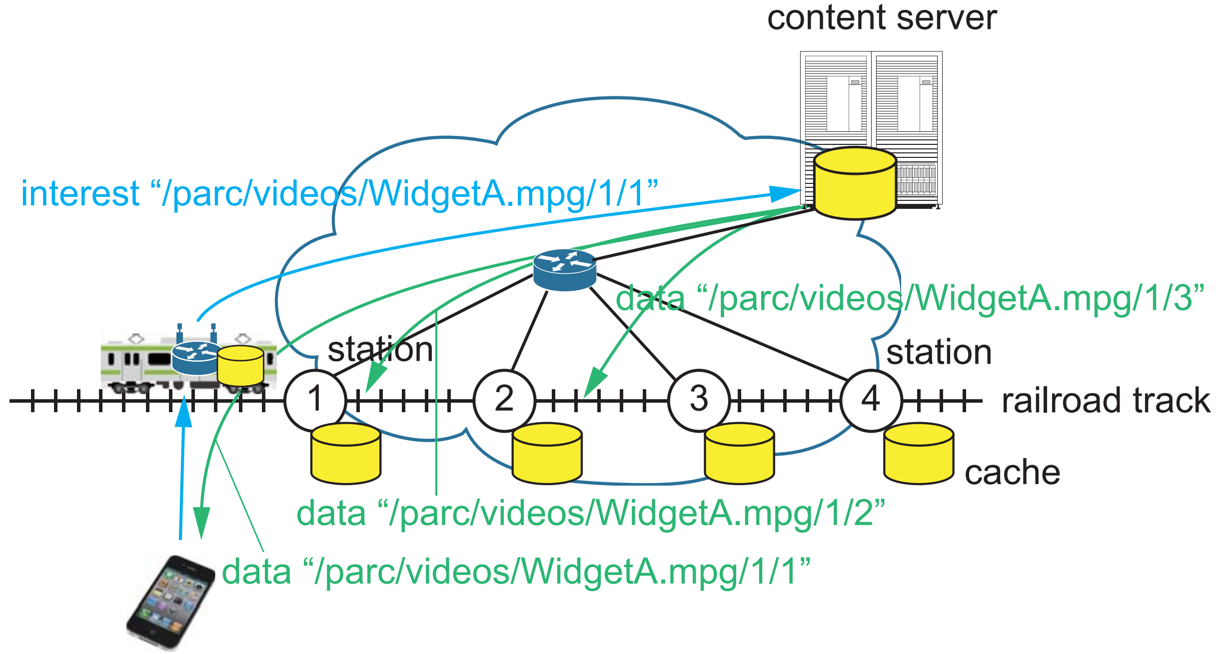
- Explosion of mobile video traffic: video traffic increase 11 times from 2013 to 2018.
- Mobile video traffic shares about 70% of mobile traffic.



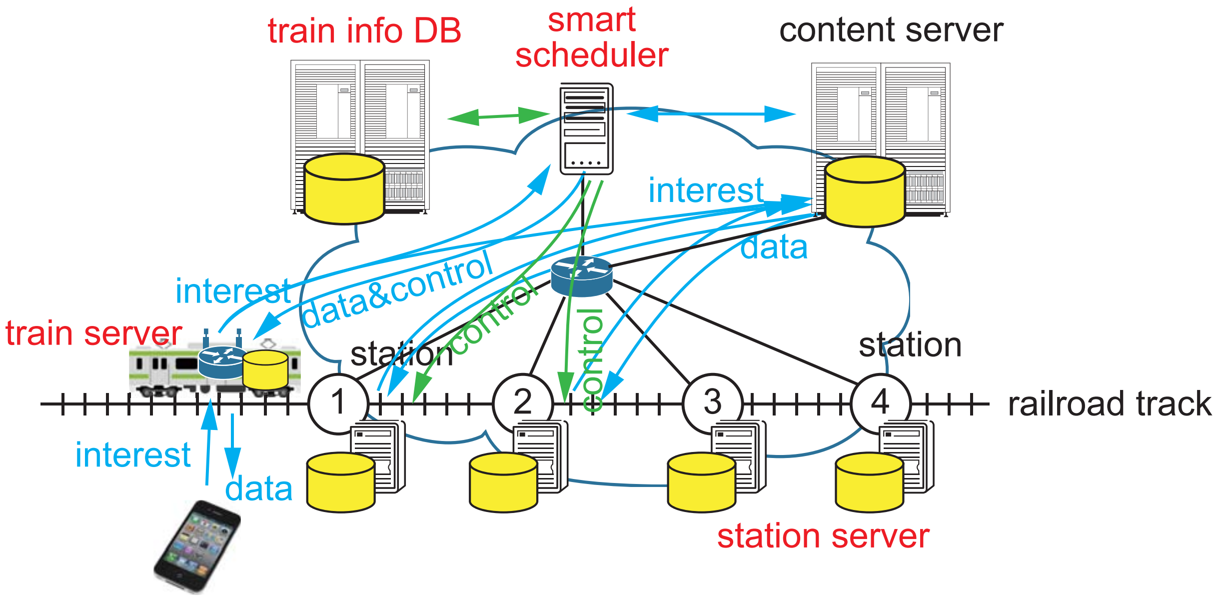
- Objective: Reduction of traffic and energy consumption by installing network infrastructure in public transportation systems
  - The idea of this work was developed in GreenICN project. The implementation for the field experiment was supported by Ministry of Internal Affairs and Communications as a part of the Project for Promotion of Advanced Communication Applications Development.

Benefit of Using NDN

- Name-based addressing help predicting content to be requested in the near future in network layer.



- Also name helps aggregating multiple video sessions from the server to a single session with multiple sessions from caches.



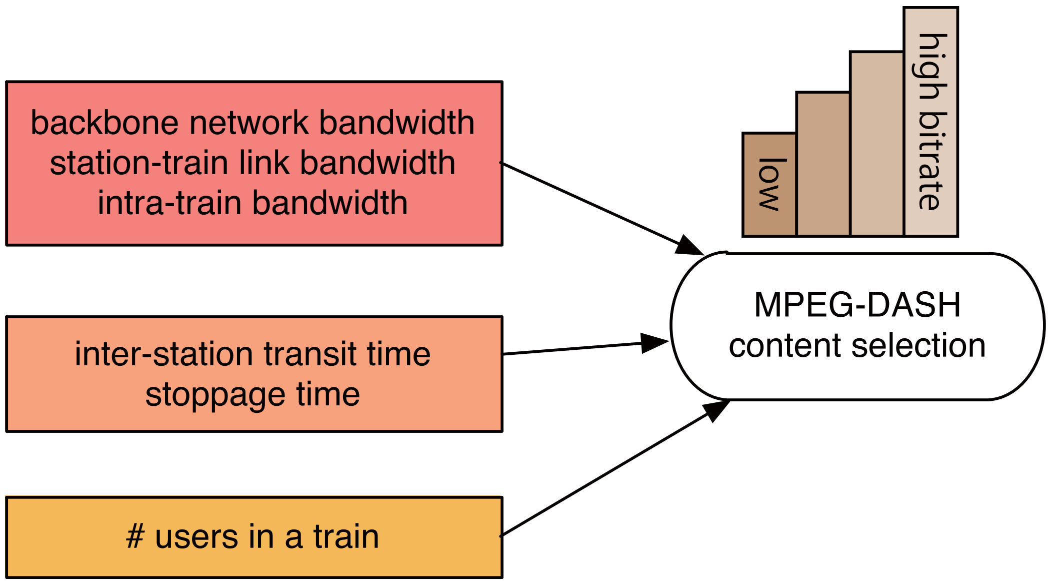
- Smart Scheduler:
  - It determines content quality and the amount of segments to deliver, and selects delivery locations and timing.
  - It also communicates with station servers to inform them to transmit appropriate interest packets.
  - The control message protocol is not determined at this moment and IP is used in the field experiment.

Architecture

- Train Information Database:
  - It holds train schedule to be used to schedule video content delivery.
- Station Server:
  - It generates interest packets according instruction given by the smart scheduler, caches the delivered content.
  - It also delivers the cached content to the appropriate train server.
- Train Server:
  - It is an ordinary NDN router which establishes a broadband communication path, such as millimeter wavy wireless connection, with station servers when the train passes stations.
  - It has Wi-Fi interface to communicate with mobile phones.

Smart Scheduler

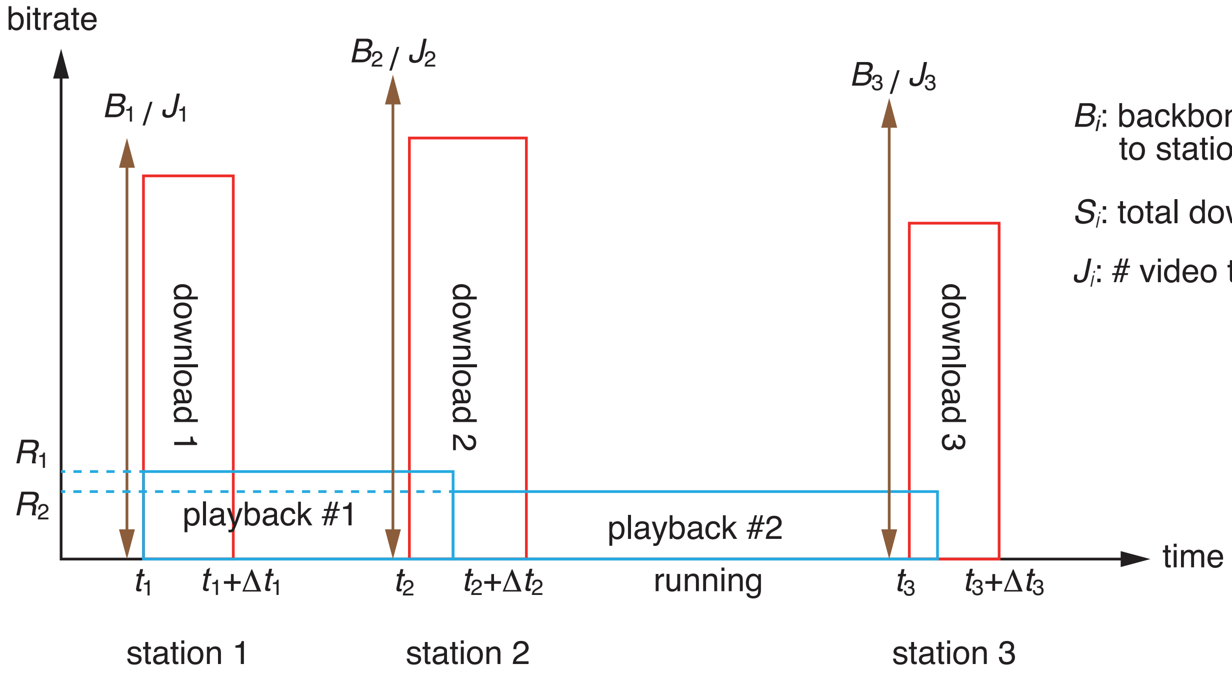
Smart scheduler dynamically selects MPEG-DASH contents depending on transit time between stations, stoppage time, network bandwidth (server – station – train – user), number of users in a train, to sustain uninterrupted video streaming.



Smart Scheduler

Select the content rate R_i that satisfies:

- Proactive caching condition: $S_i \leq B_i(t_{i+1} - t_0)$
- Continuous playback condition: $S_i / J_i \geq R_i(t_{i+1} - t_i)$
- Smooth playback condition: $D / J_i \geq R_i$,
  where D is the estimated bandwidth between a train server and a user device



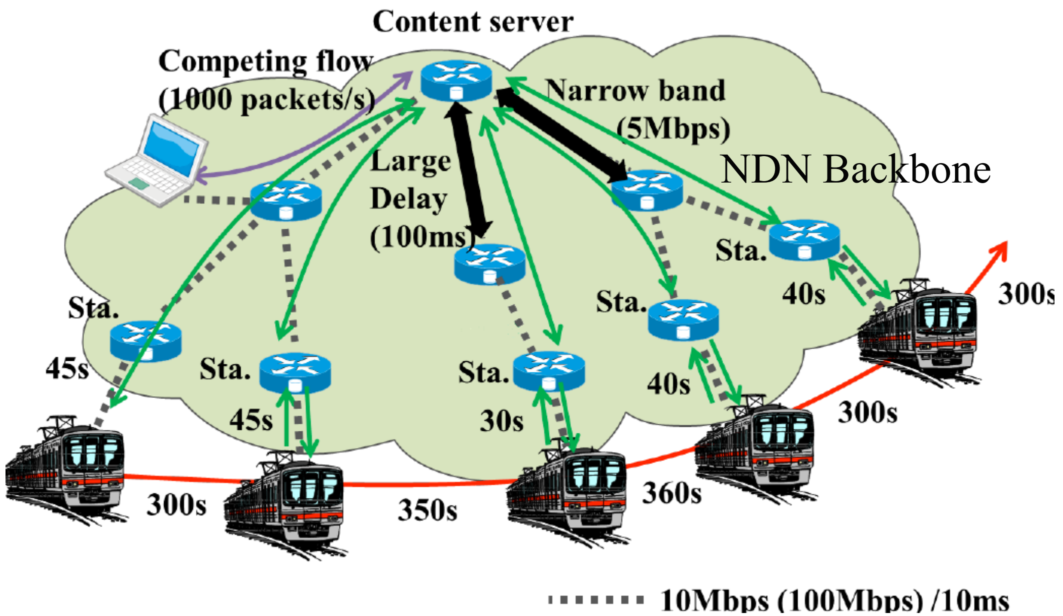
B_i: backbone link bandwidth from server to station i

S_i: total downloaded data size at station i

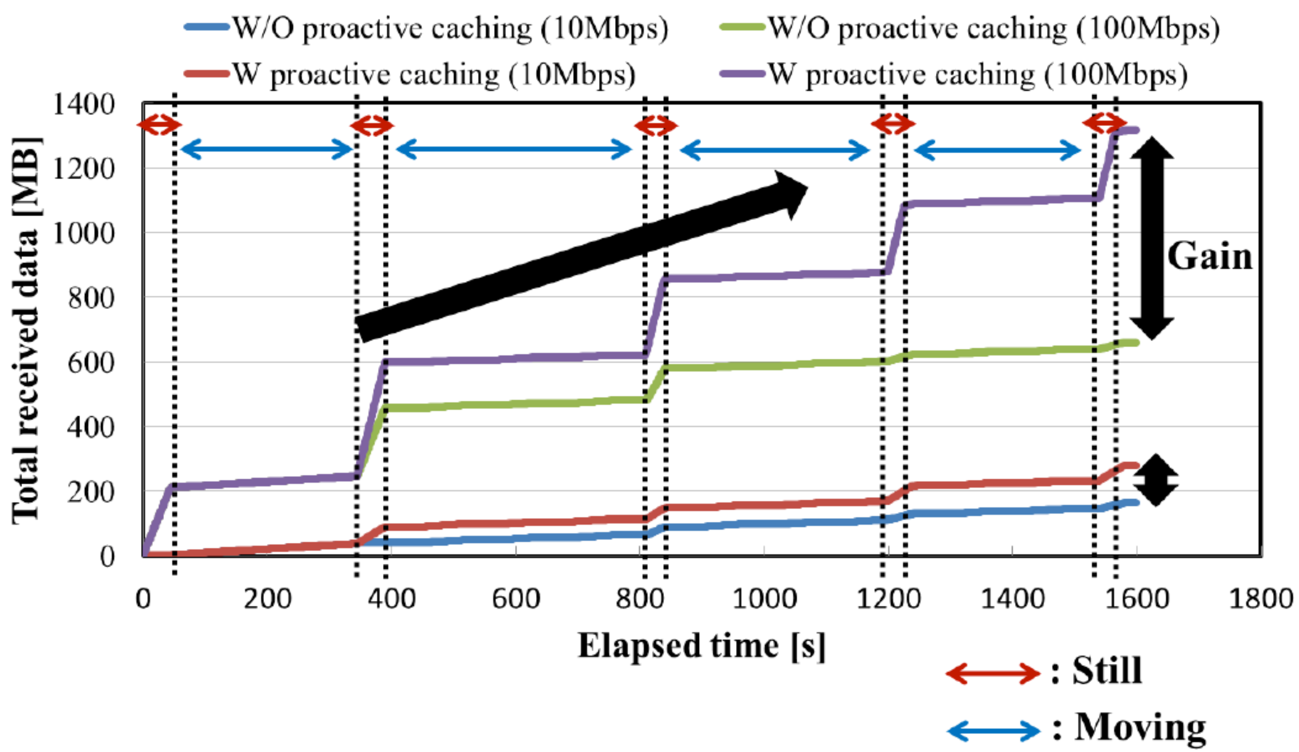
J_i: # video titles between station i and i+1

Simulation

- Performance of proactive caching is evaluated on NDNsim.
- The assumed network environment is:



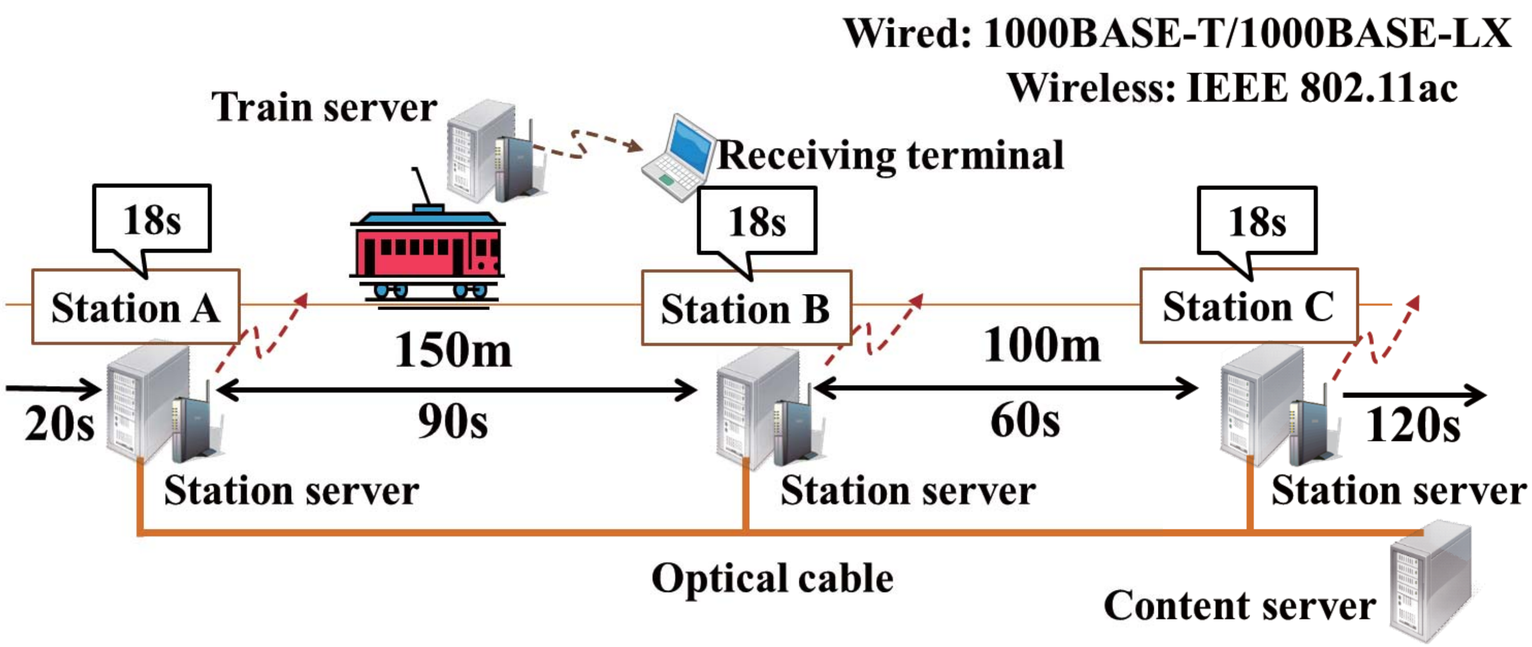
Simulation



- When there are QoS degradations, such as larger delay and narrower bandwidth, in the nearest link to the content server, the gain for our proposal is larger.

Field Experiment

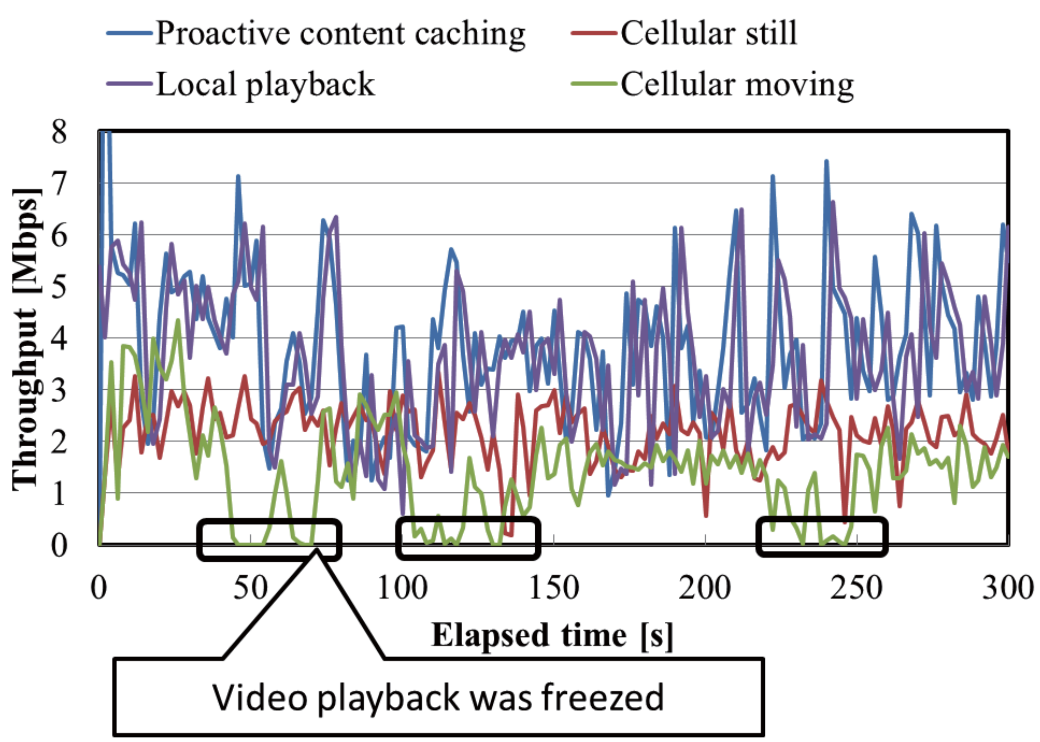
- Field experiment using real trains is carried out using our prototype system[1].



[1] Field experiment environment was provided by Keikyu Corporation, a railroad company.

Field Experiment

- Proactive caching prevent dropping throughput and sustain continuous playback.



Conclusions

- We proposed and evaluated proactive caching in public transportation environment.
- Proactive caching can maintain uninterrupted video playback by properly caching future content at appropriate cache.