

DTN technology as enabler of cost-efficient networking with wired and wireless integration

- DTNRG in IETF76 -

Masato Tsuru ^{*1,*2}

tsuru@cse.kyutech.ac.jp

Shinya Yamamura ^{*2}, **Akira Nagata** ^{*2}

{yamamura, [nagata](mailto:nagata@nict.go.jp)}@nict.go.jp

^{*1}: Network Design Research Center, Kyushu Institute of Technology (JAPAN)

^{*2}: Service Platform Architecture Research Center,

National Institute of Information and Communications Technology (JAPAN)

DTN-related Project Structure in NICT

NICT: National Inst. of Information & Comm. Technology

- ✓ An incorporated administrative agency for R&D on Information Comm. Technologies supported by MIC (Ministry of Internal Affairs and Comm.) as the competent authority (<http://nict.go.jp/index.html>)



1. Virtually Sustainable Access Networking Project (2006-2008)

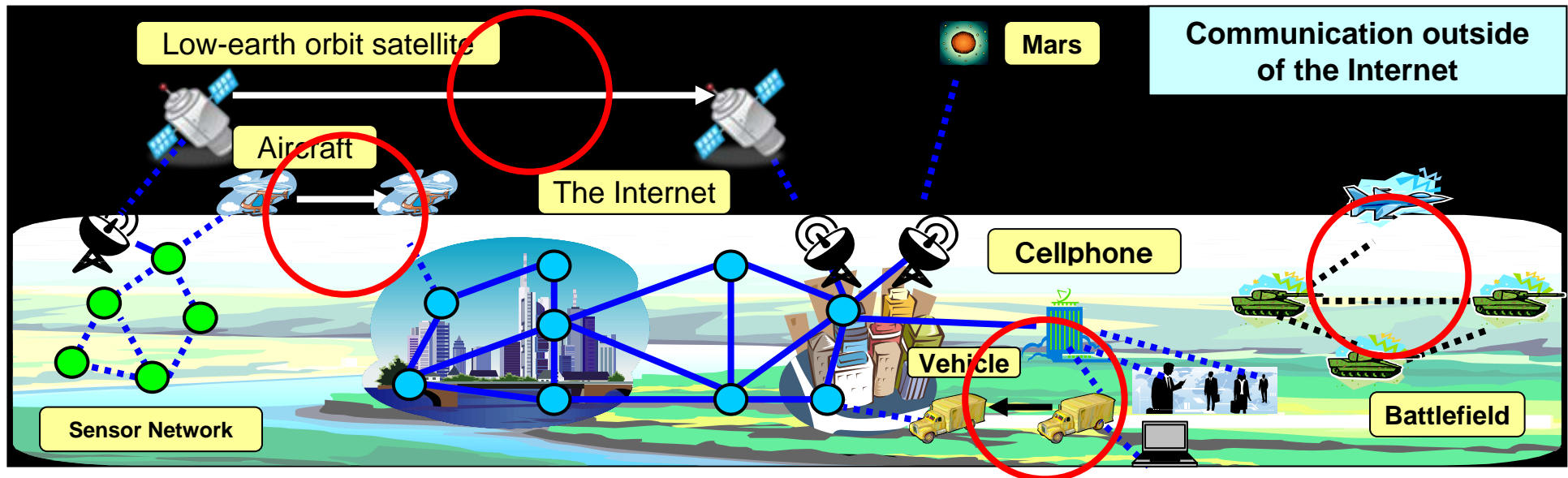
- ✓ Fundamental techniques: Epidemic routing, Network coding, Wifi rerouting, Multi-path transport, etc.
- ✓ Collaborated by Kyushu Inst. Tech., Osaka Univ. and Kwansei Gakuin Univ.
 - T. Matsuda, T. Takine: (p,q)-epidemic routing for sparsely populated mobile ad hoc networks, IEEE J-SAC 26(5):783-793.
 - T. Matsuda, T. Noguchi, T. Takine: Broadcasting with Randomized Network Coding in Dense Wireless Ad Hoc Networks, IEICE Trans. Comm. E91-B(10):3216-3225

2. Integrated Wired and Wireless Network Platform Project (2009-2010)

- ✓ Under **JGN2plus R&D on Platform Technologies for the New Generation Network** by NICT Service Platform Architecture Research Center
- ✓ More architectural R&D towards Future Internet services

DTN: Delay and Disruption Tolerant Networking

- DTN technology is designed to overcome limitations in connectivity or performance due to
 - ✓ Opportunistic or scheduled intermittent links,
 - ✓ Huge error rate links (packet losses),
 - ✓ Huge or highly variable delay links,
 - ✓ Link bandwidth/loss/delay asymmetry,
 - ✓ Internetworking among heterogeneous network architectures, .. etc
- Originally targeting challenged environments such as Inter-Planetary Internet
- But later... great generality and importance are known.



DTN and Future Internet Research

- A general framework for cost-efficient information exchange over discontinuous space and time
- As a basis for asynchronous (non-realtime) comm. across very heterogeneous networks

DTN-related R&D proposals in NSF NeTS FIND (Future Internet Design)

✓ Postcards from the Edge: A Cache-and-Forward Architecture for the Future Internet

□ Roy Yates, Dipankar Raychaudhuri, Sanjoy Paul, James Kurose (Rutgers WINLAB; UMass)

✓ The-Day-After Networks: A First-Response Edge-Network Architecture for Disaster Relief

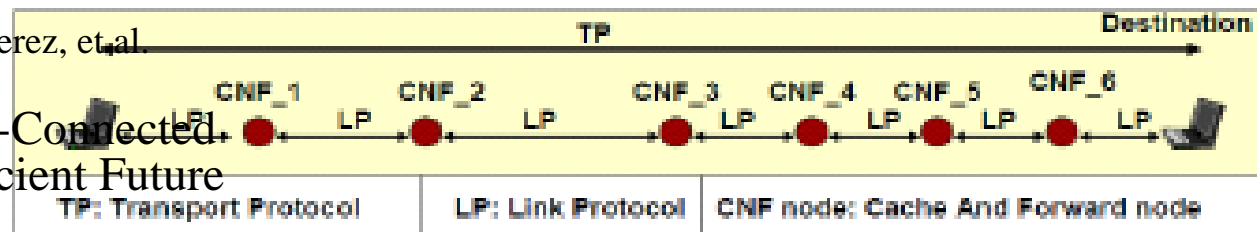
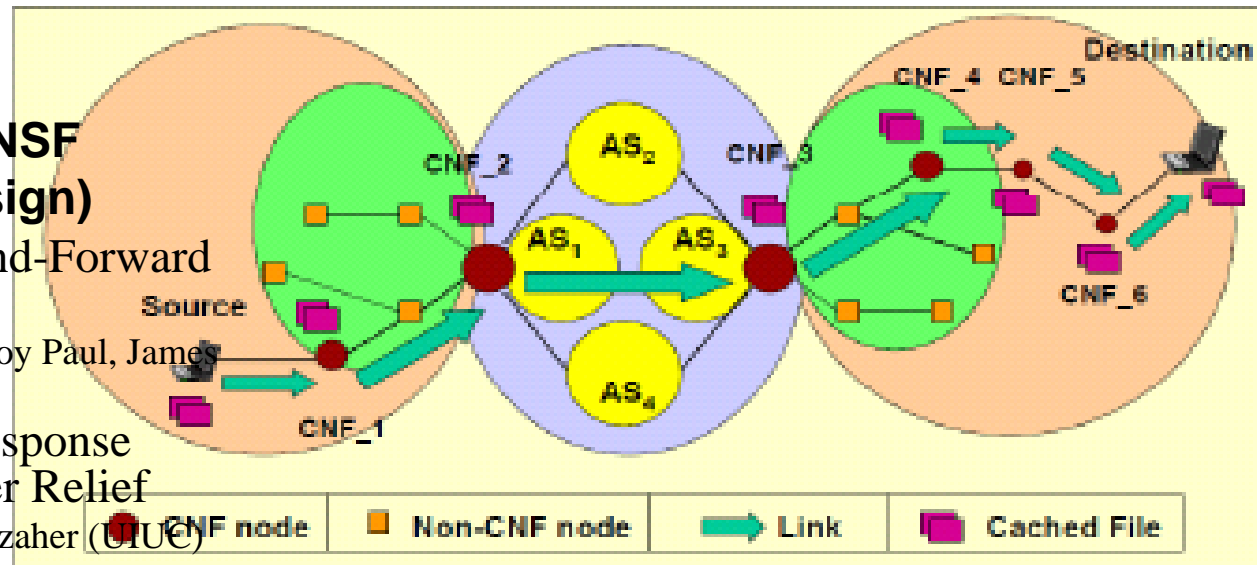
□ Haiyun Luo, Robin Kravets, Tarek Abdelzaher (UIUC)

✓ Transient Network Architecture

□ Robert Kahn, Chaouki Abdallah, Henry Jerez, et al. (CNRI)

✓ Architectural Support for Selectively-Connected End Systems: Enabling an Energy-Efficient Future Internet

□ Mark Allman, Vern Paxson, Ken Christensen, Bruce Nordman (ICSI, University of South Florida, LBNL)

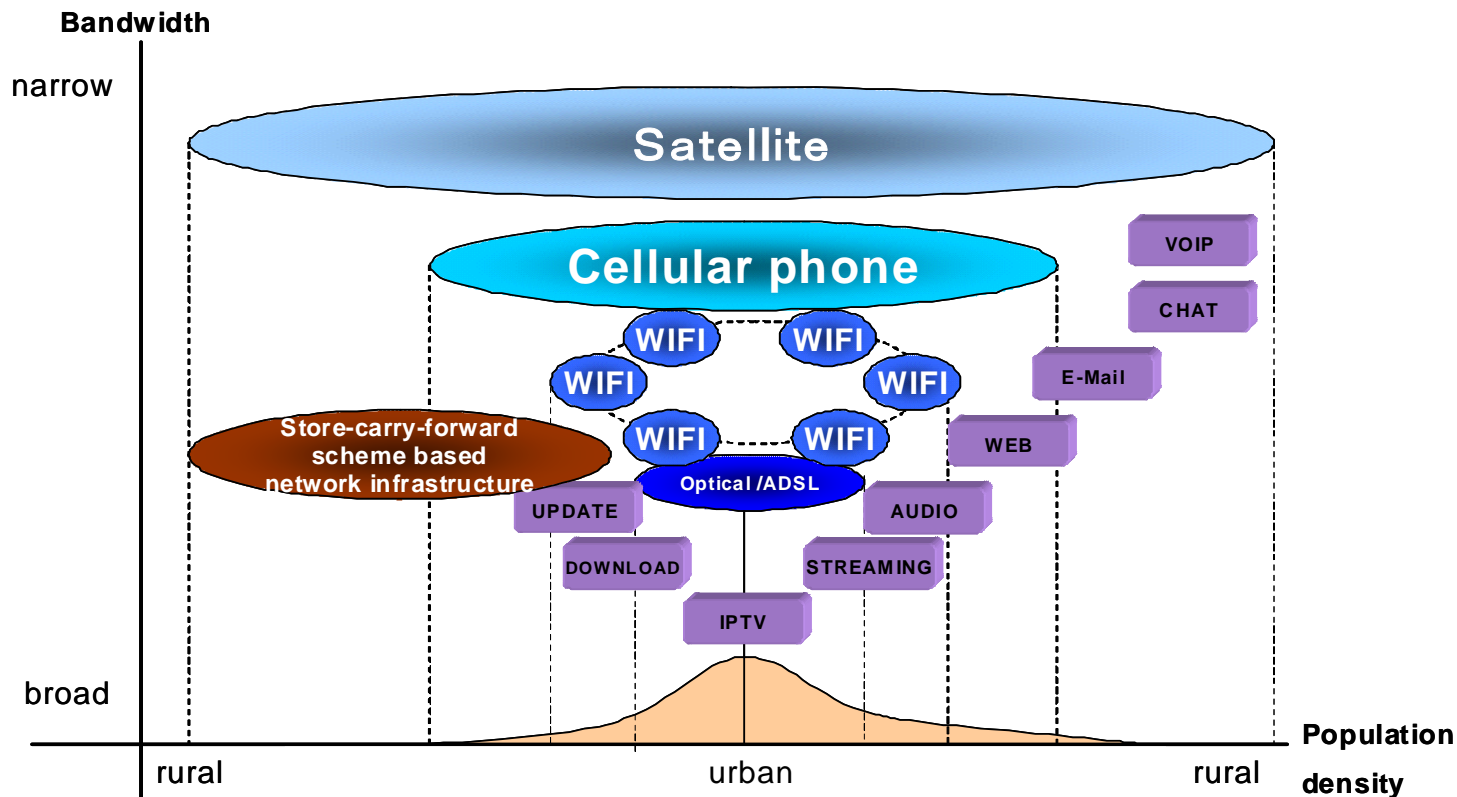


Cache-and-Forward Network System Overview

Our project

■ DTN-based R&D for future network services

- ❑ For cost-efficient networking in rural and urban life rather than only for exotic environments: **Efficient use of limited wireless resources and/or Saving energy**
- ❑ Fully exploiting a combination of diverse network techniques for non-realtime comm.: **Integrated Wired and Wireless Network Platform**
 - ✓ Universal identifier and Late binding
 - ✓ Store-(carry-)forward message delivery
 - ✓ A variety of Space and Time and Freq. (cognitive ratio) resource scheduling schemes

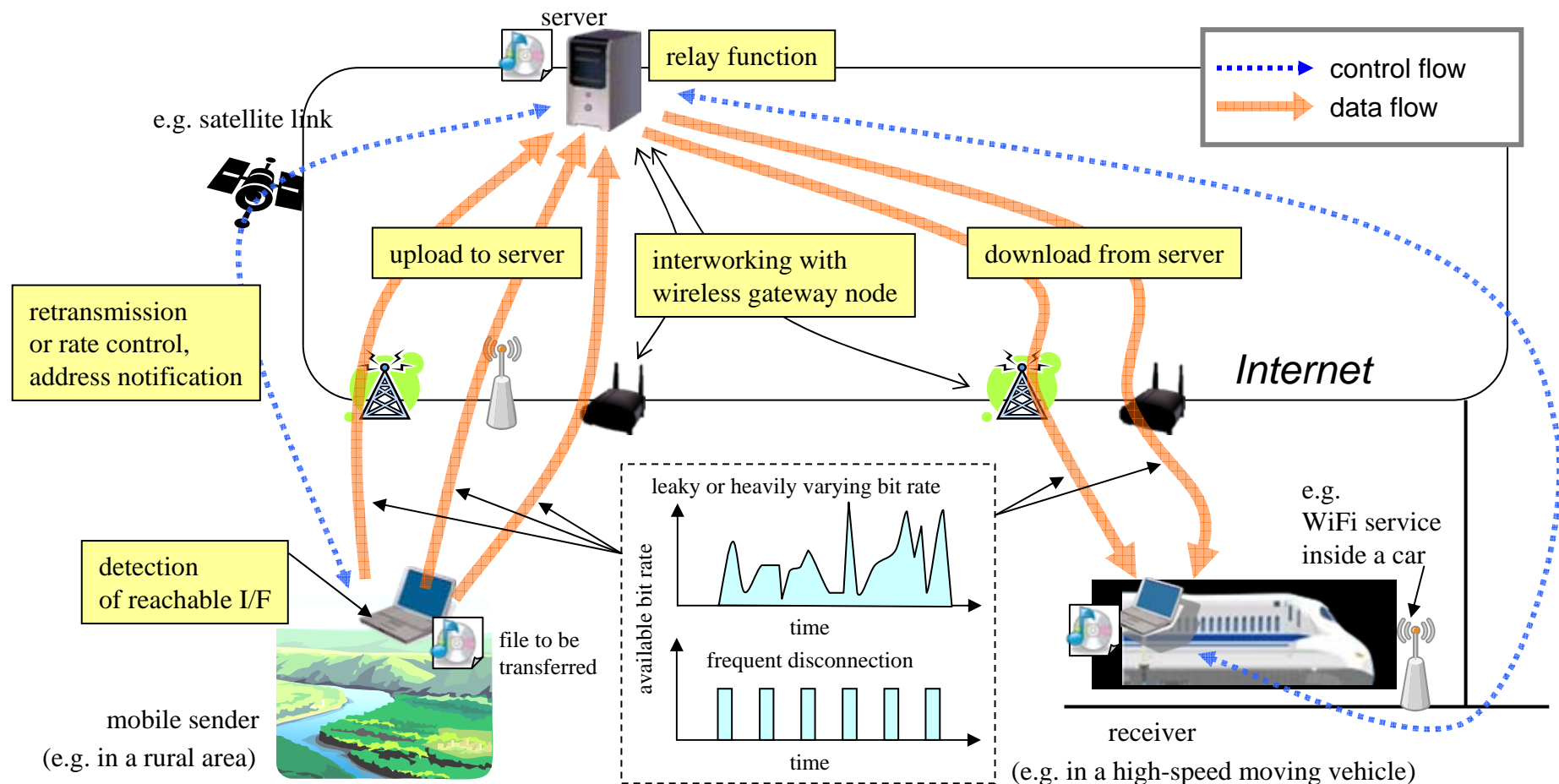


Our project (cont.)

1. Integrated Multi-network Data Transfer Proxy Agent and its Protocol
 - Large data transfer over multiple inferior networks between intermediate nodes (proxy agents)
 - Integrating wide-area, stable but low-speed networks and narrow-area, high-speed but unstable, intermittent networks
 - WiFi, Cellar, Satellite, WiMAX,...
 - Separating data transmission flows and control flows
2. Store-Carry-Forward Based Access Network Infrastructure
 - **Virtual Segment (VS)**: a virtual access network along roads supporting non-realtime large data exchange
 - Integrating short-range wireless comm and long-range wired/wireless infrastructure based on store-carry-forward scheme by vehicles (buses, cars, trains, ...)

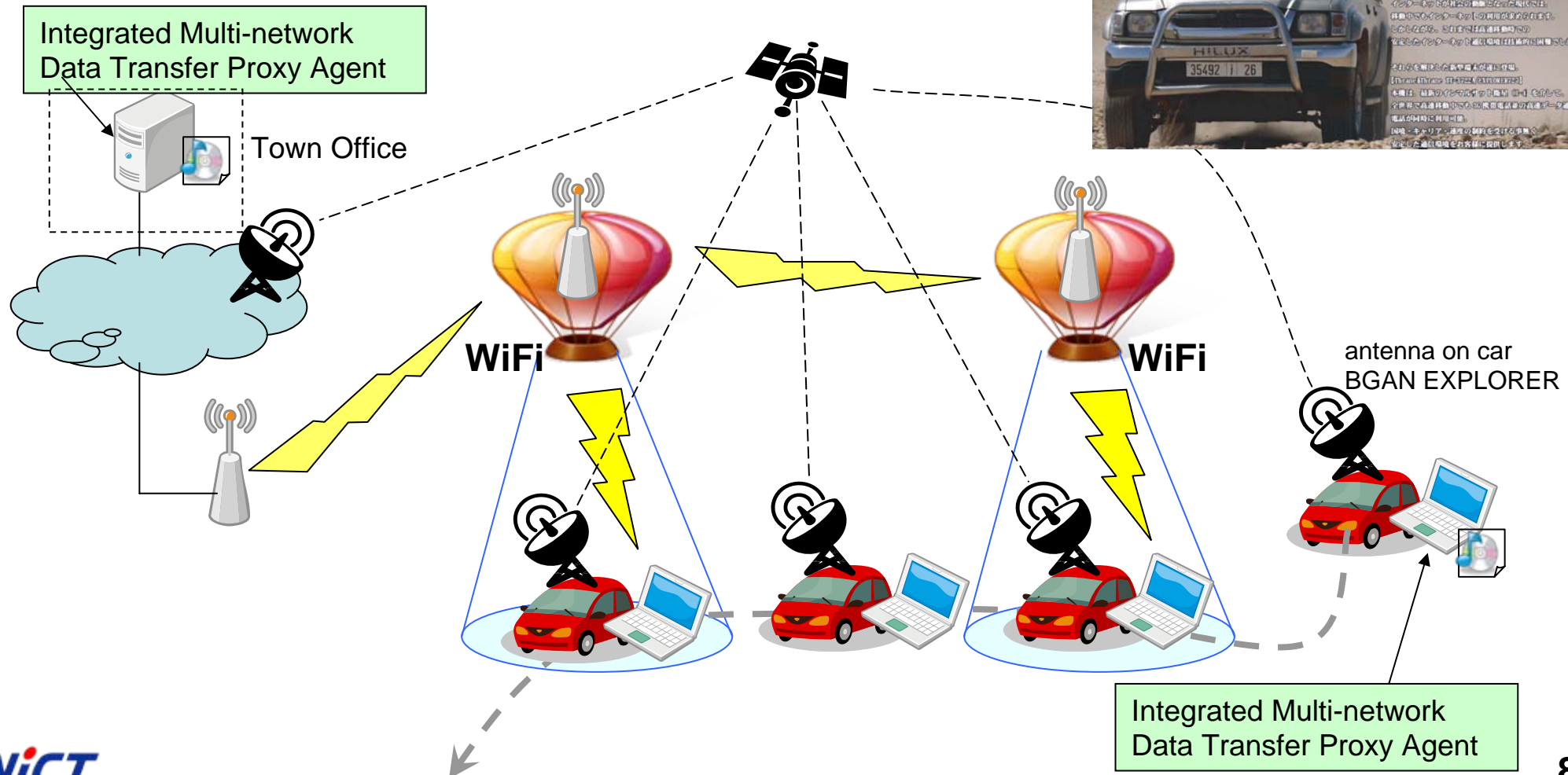
A Concept of Integrated Multi-network Data Transfer

- Integrating wide-area, stable but low-speed networks and narrow-area, high-speed but unstable, intermittent networks (WiFi, Cellular, Satellite, WiMAX,...)
- As a new transport protocol between Proxy Agents, especially by separating data transmission flows and control flows



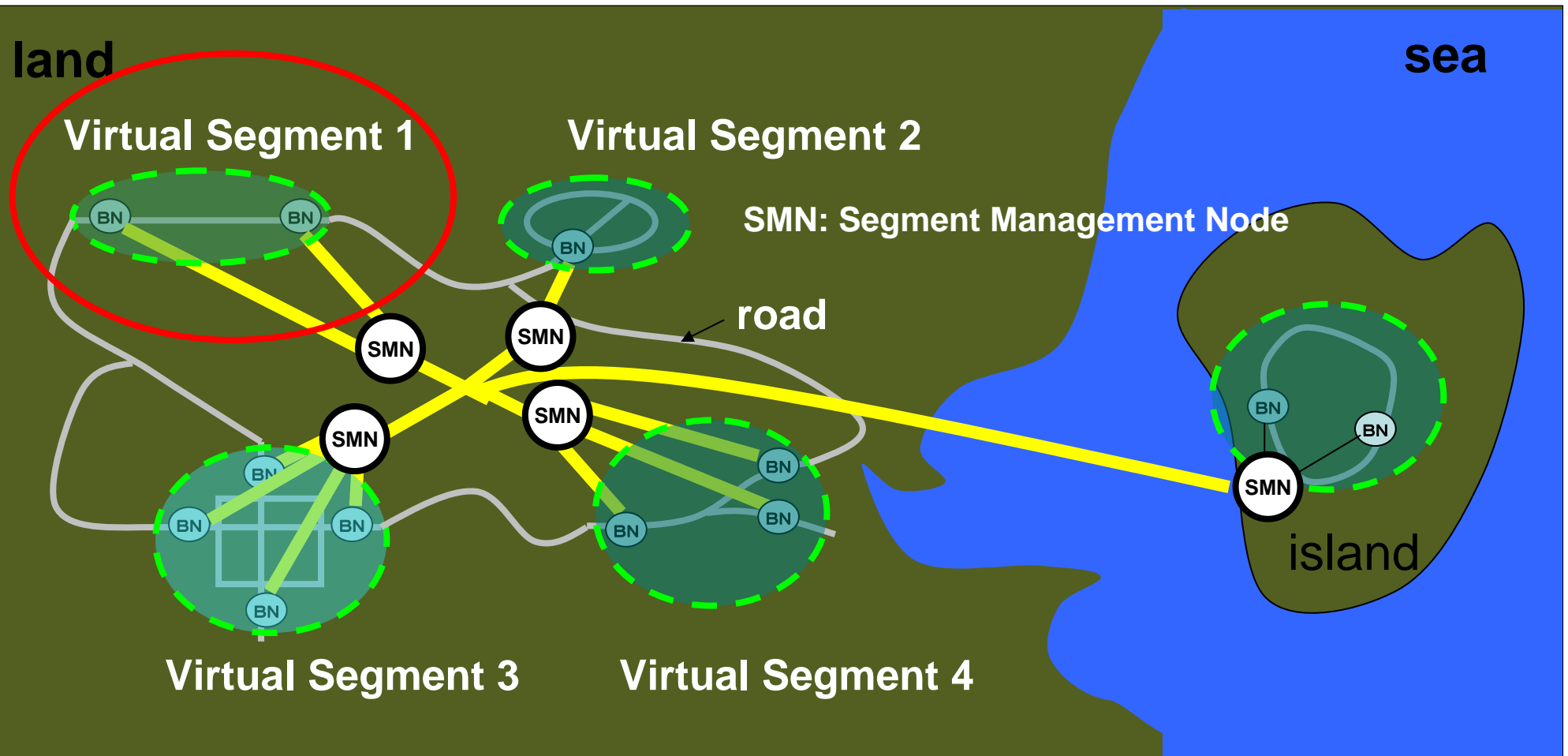
An application-level Experiment (Plan)

- Emergency networking in Disaster
 - by Wifi AP at balloons and satellite comm.



A Concept of Virtual Segments

- Divide the communication area to some virtual segments (VSs)
- In a VS, messages are transferred in a SCF manner by vehicles
- Take a shortcut between VSs via connected links



Schematic description of VS

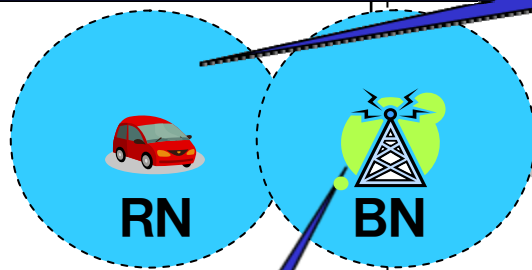
Relay Node (RN)

Vehicle that travels along roads and has the ability to store, carry, and forward data from/to correspondent node nearby.

Correspondent Node (CN)

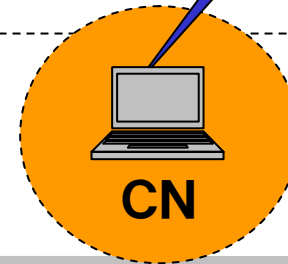
Each stationary or mobile comm. user.

Network



Base Node (BN)

Stationary gateway that comm. with and controls the relay node passing near to the BN and also stores the data to be collected and delivered.

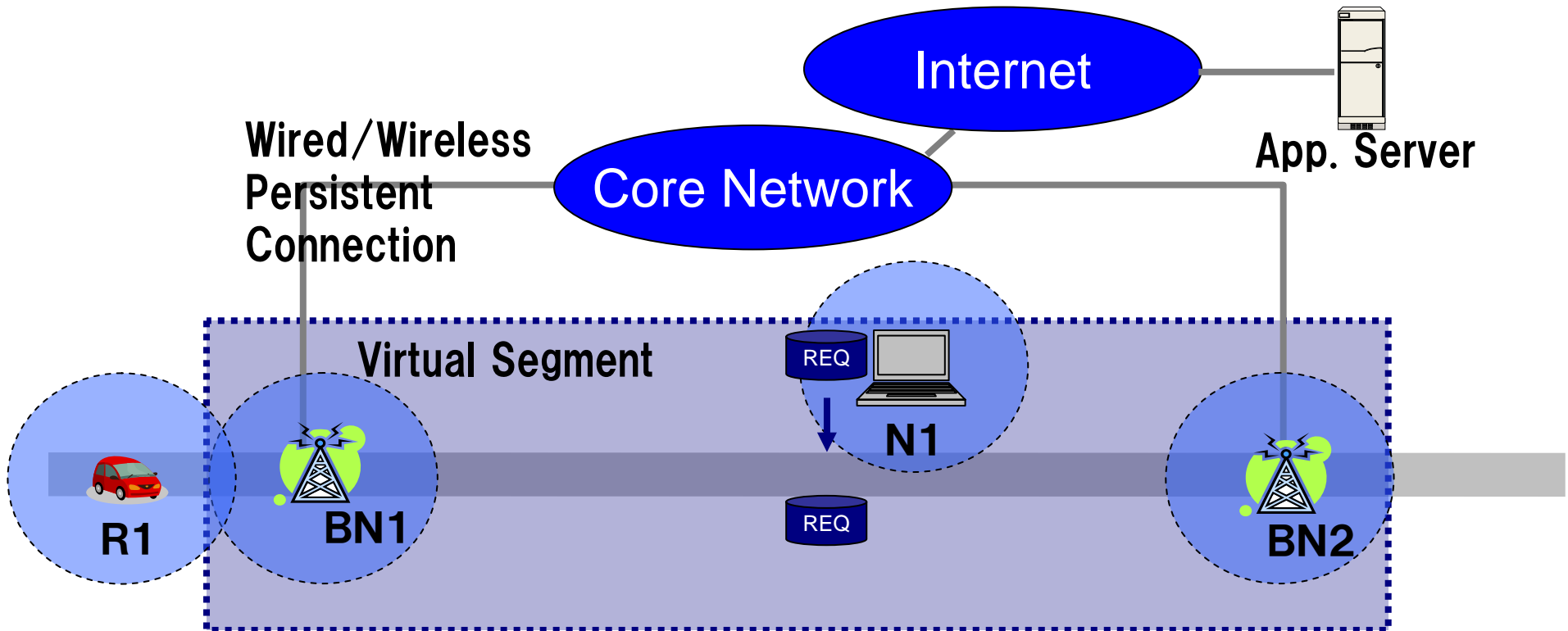


Virtual Segment

Geographical region surrounded and delimited by one or more BNs along the roads.

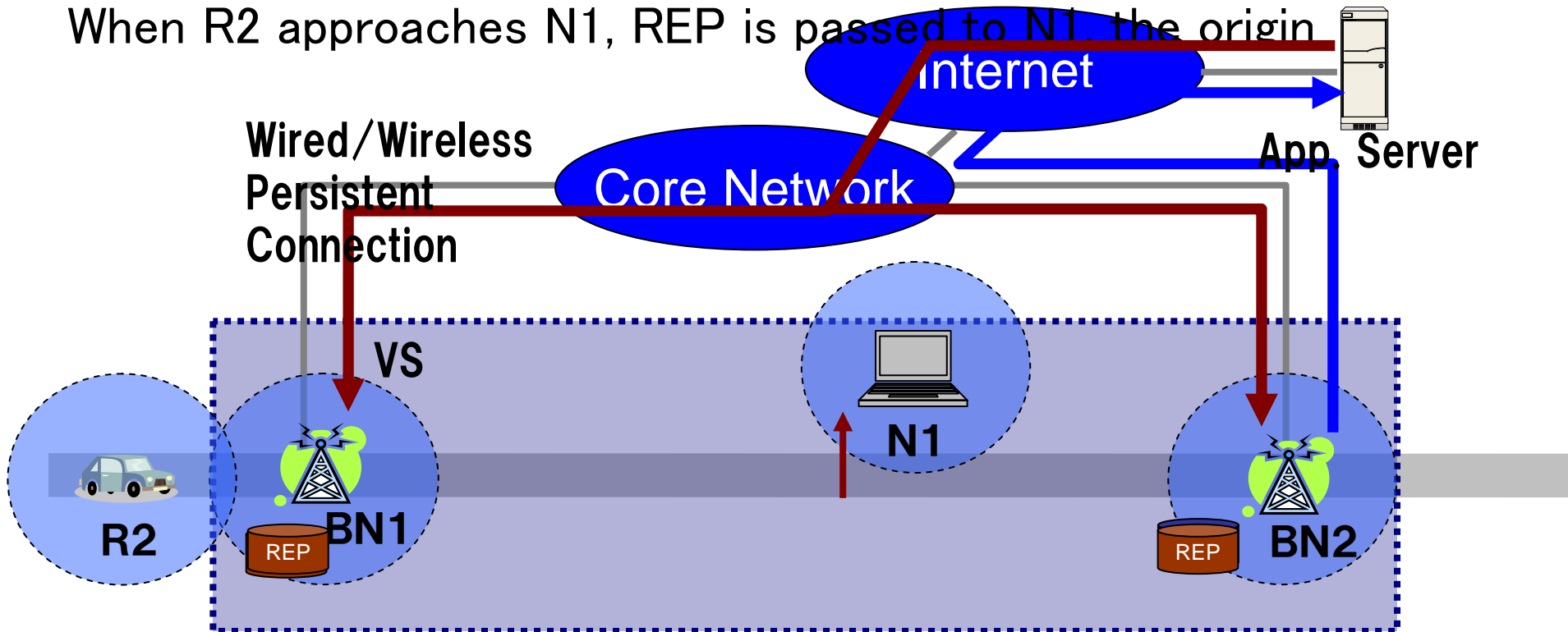
Message exchange between VS and Internet

1. User N1 wants to send a request message (REQ) to Internet
2. Car R1 crossing BaseNode BN1 acts as a relay in this VS
3. When R1 approaches N1, REQ is passed to N1
4. When R1 approaches BaseNode BN2, REQ is passed to BN2

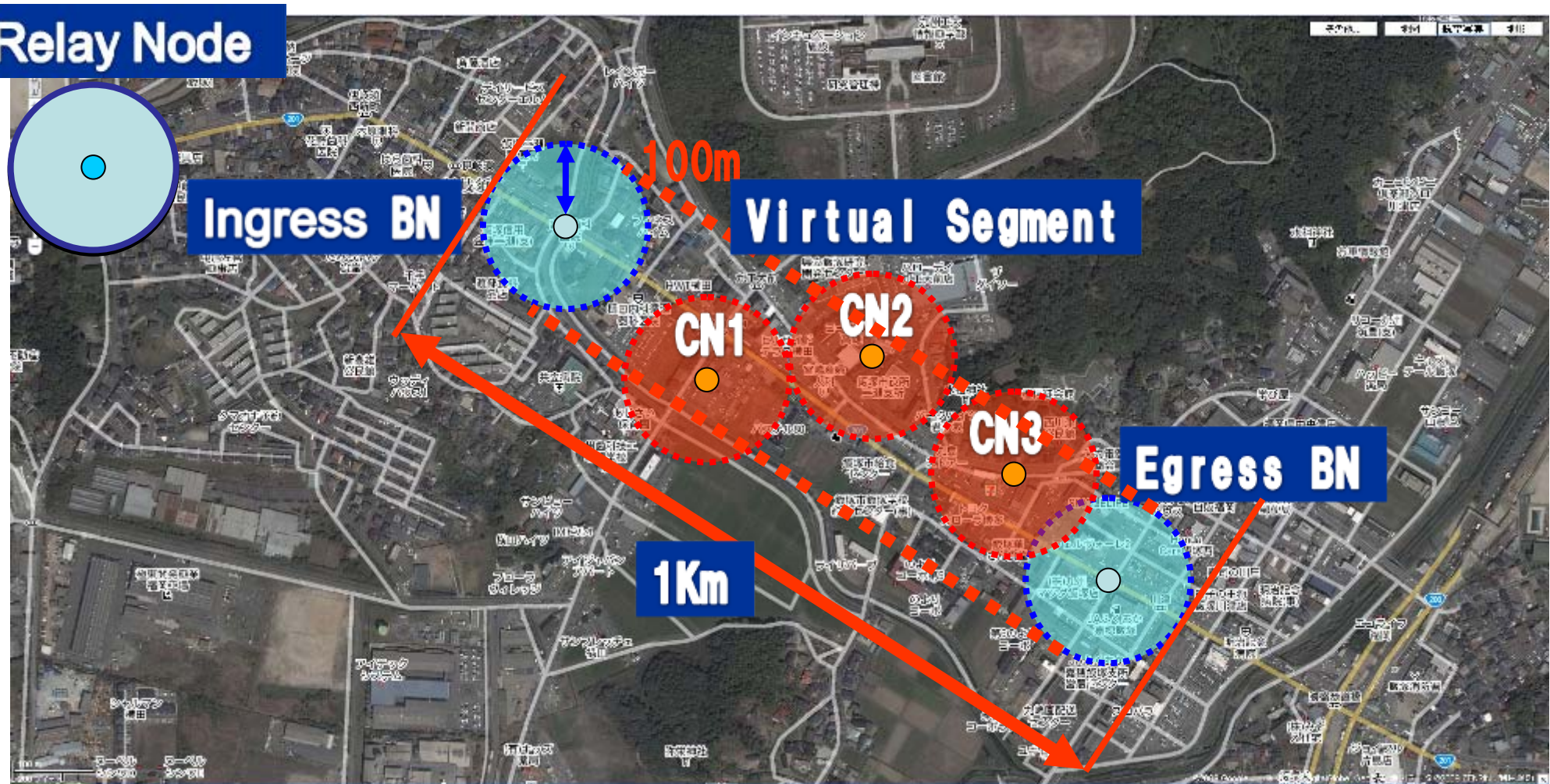


Message exchange between VS and Internet (cont.)

5. BaseNode BN2 sends REQ to the destination (the application server) on the Internet through a core network
6. A reply message (REP) is sent to both BN1 and BN2
7. When R2 approaches BN1, REP is passed to R2
8. When R2 approaches N1, REP is passed to N1, the origin



An image of deployment of Virtual Segment

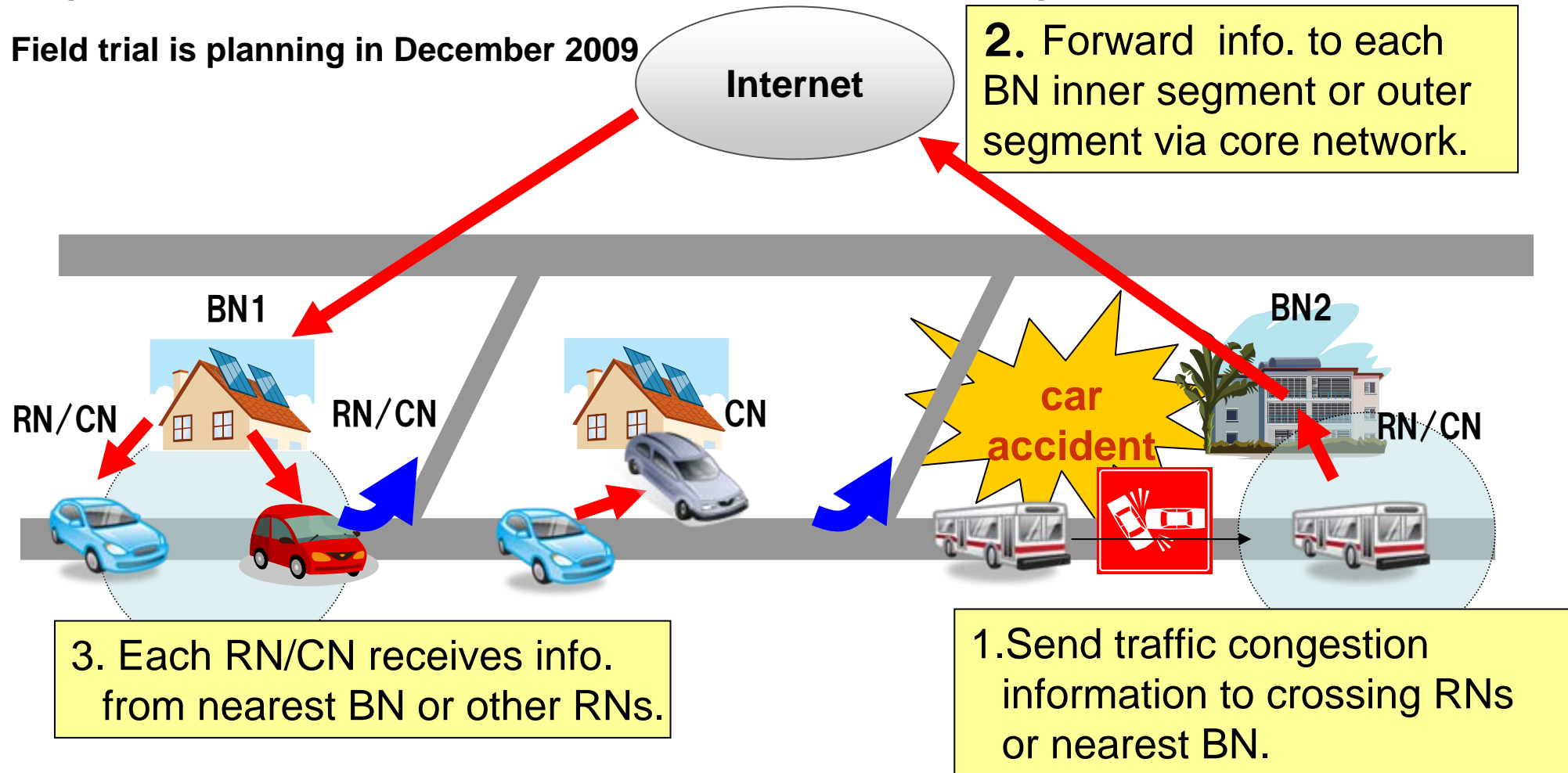


A field trial is being planned on December 2009 at Izuka city.

An application-level Experiment (Plan)

Traffic congestion information advertisement (traffic information, accident information)

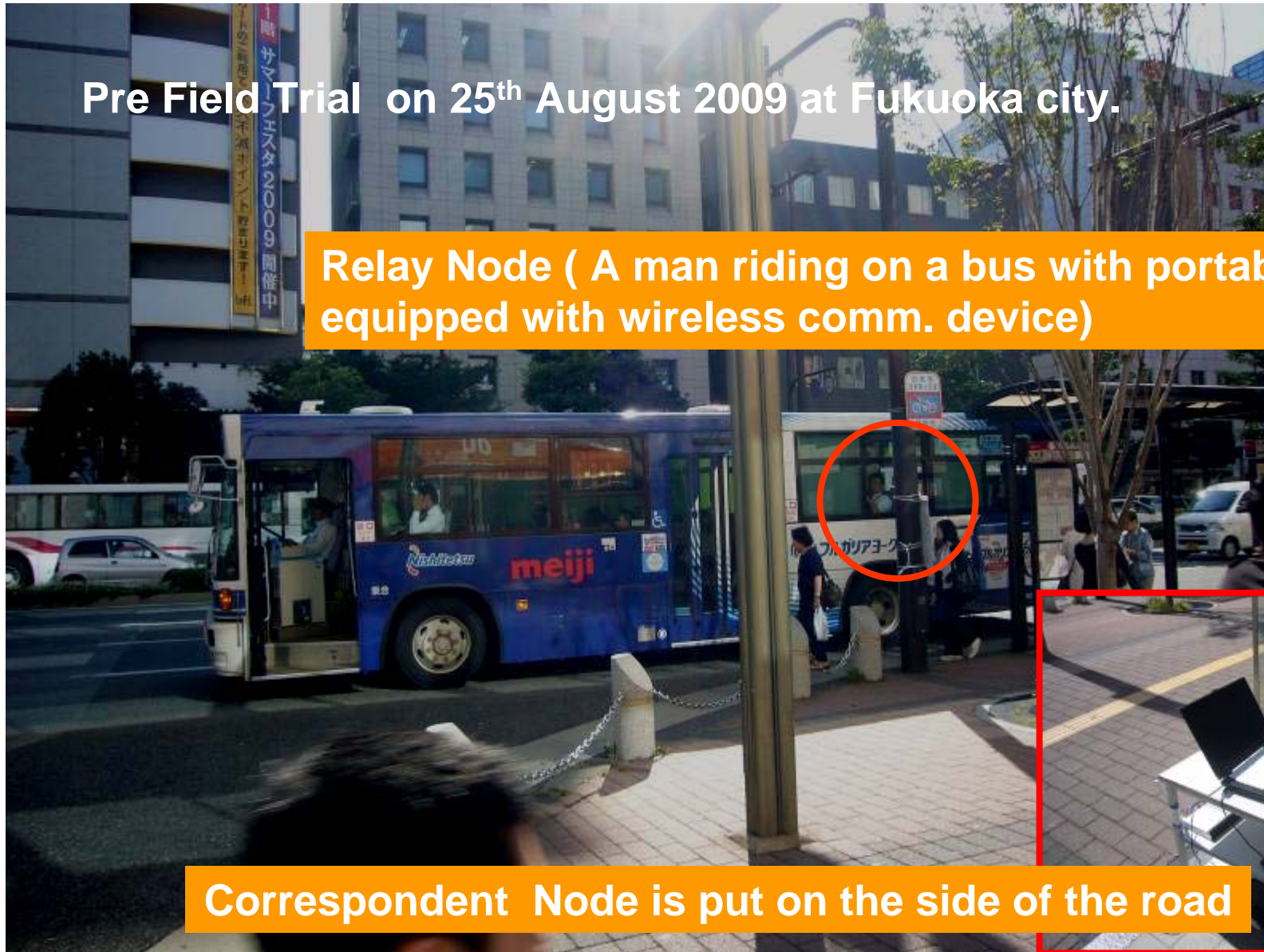
Field trial is planning in December 2009



An image of pre-experiments

Pre Field Trial on 25th August 2009 at Fukuoka city.

Relay Node (A man riding on a bus with portable pc equipped with wireless comm. device)

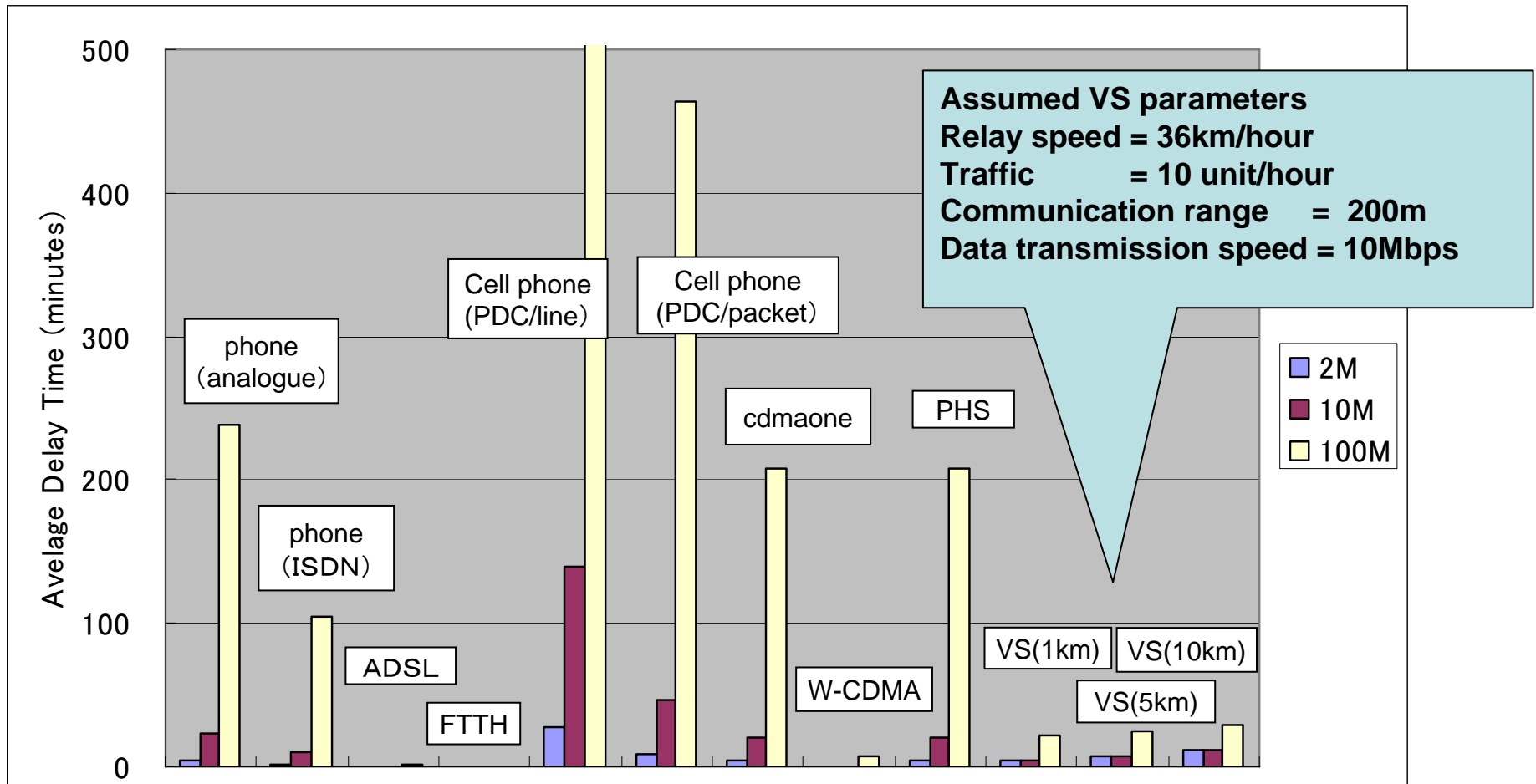


Correspondent Node is put on the side of the road



Can Store-carry-forward be practical?

File Transmission Time comparison



VS can provide throughput performance comparable to the narrowband media

Can Store–carry–forward be practical? (cont.)

■ Amazon Web Services (AWS) Import/Export

- In uploading huge data to the centers, the time required to prepare and ship a USB to a near AWS site is shorter than that by using a limited Internet connection

- <http://aws.amazon.com/importexport/>

■ Pigeon Networking☺

- South Africa pigeon 'faster than broadband (ADSL)' for 4GB data transfer across country

- <http://news.bbc.co.uk/2/hi/africa/8248056.stm>

- Homing pigeons get down to business, ferrying rafting company photos

- http://www.denverpost.com/news/ci_6209735



Concluding Remarks

- In Japan, DTN-related research (in NICT) arose in 2006 and have much attention recently
 - ▣ NICT is leading
 - ▣ In corporation with universities (Osaka-u, U-Tokyo, Kyutech, Kuwansei Gakuin-U, etc.)
 - ▣ Commercial Interest slowly increasing...
- The current NICT project (2009-2010) aims at
 - ▣ Integrated Wired and Wireless Network Platform
 - ▣ as cost-efficient networking platform for non-real-time, asynchronous, and large-sized data comm.
- In the next project circle from 2011, DTN, other wireless-related research including cognitive radio, and Future Internet research may be (hopefully) more collaborated in both NICT and Japan.