

*LAAS-CNRS 40<sup>th</sup> Anniversary Workshop*

# ADUN: Appliance Defined Ubiquitous Network

- Global Network Infrastructure for Real World Sensing -

October, 2008

Haruhisa Ichikawa

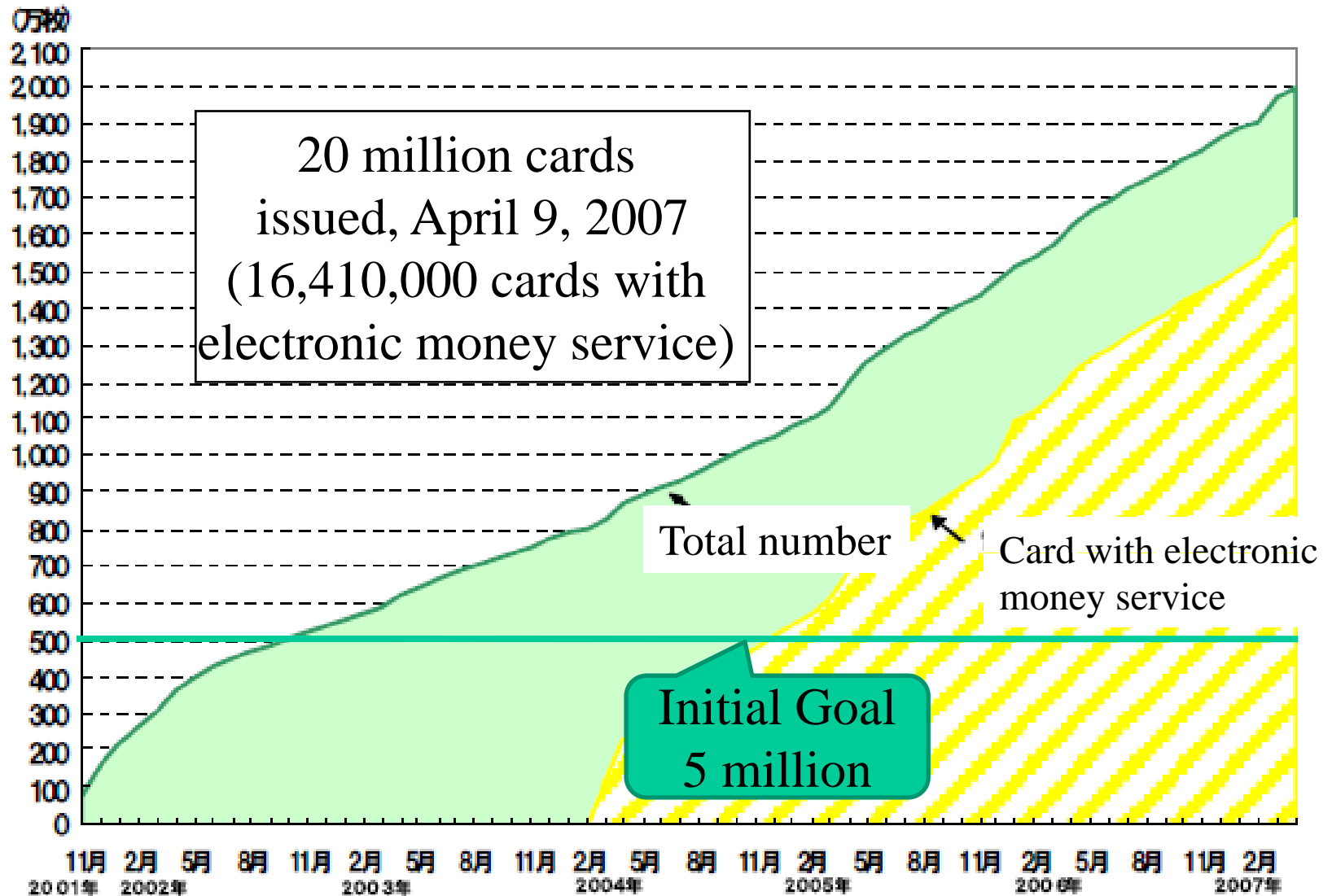
University of Electro-Communications, Tokyo

Supported by CREST/ULP, NICT

Small wireless appliances are being applied to integrate ICT infrastructures

# Improvement of Existing Infrastrures

# Japan Railway's Passive RFID Card "SUICA": Market Penetration and Service Enhancement



4  
Reported by JR East, April 10, 2007

# Integration or Convergence of Existing Infrastructure Services

# New Value Creation by Service Convergence

- End-to-end navigation by convergence of navigation systems
  - Train timetable
  - Car Navigation
  - Mobile phones with GPS

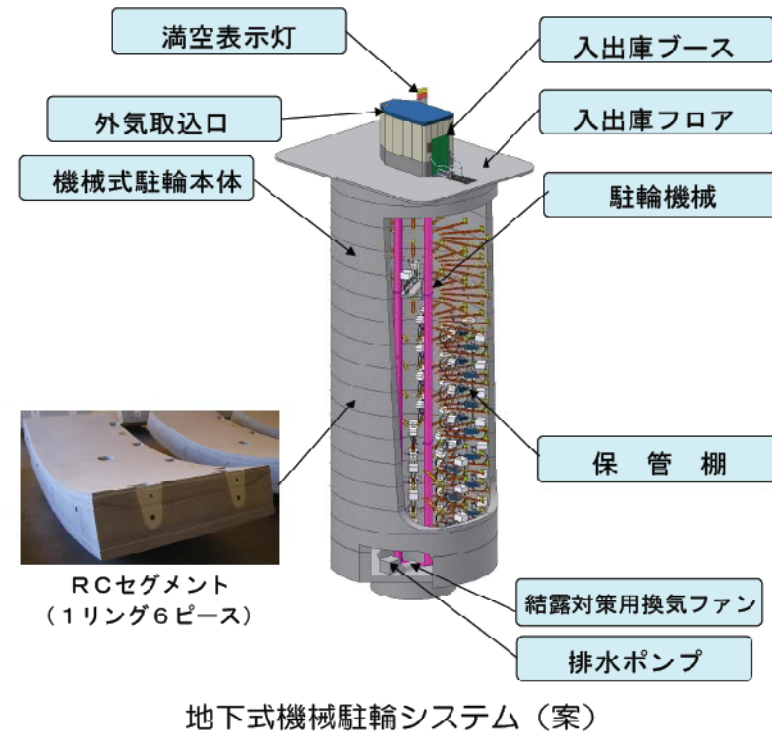


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# Creation of New Infrastructures

# Bicycle Parking Silo at Kasai Station, Edogawa Ward, Tokyo

- Objective
  - Provision of parking to 3,000 uncontrolled bicycles
  - Encouragement of bicycle usages for environment protection
- Store 9,400 bicycles
- Active RFID attached to bicycles for storing and finding them
- IC cards for retrieving them
- 5 seconds for storing, 5 to 20 seconds for retrieving
- Construction cost: 7 billion Yen
  - Fare:
    - 1,800Yen/month (1,000Yen for students)
- Impacts to Environments
  - CO2 increase: Construction, Operation
  - CO2 reduction: Car usage reduction





# Bicycle Parking Silo at Kasai Station, Edogawa Ward, Tokyo (Continued)



Active tags attached to bicycle

<http://www.news.city.edogawa.tokyo.jp/flashindex.html>

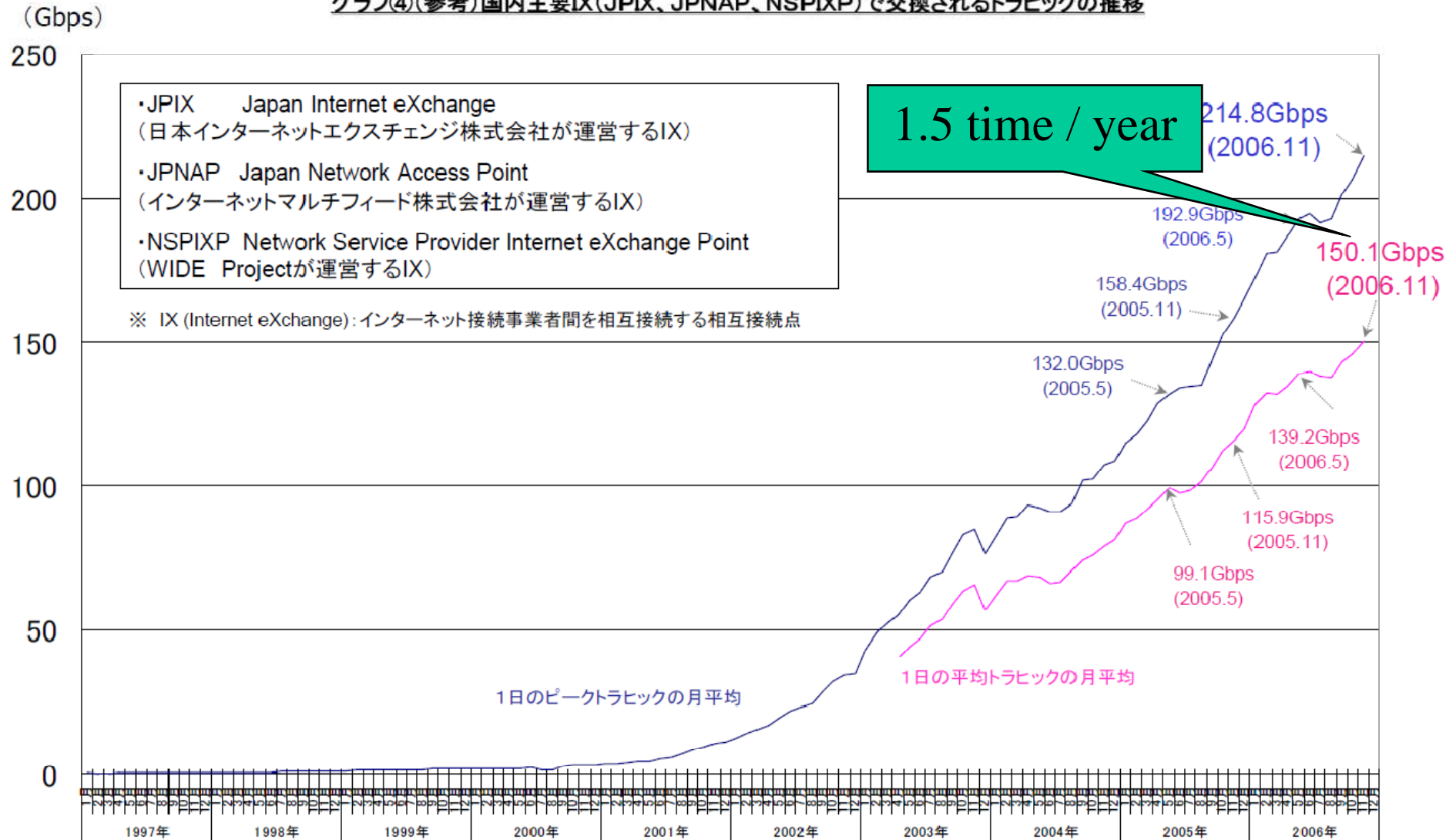
# Expectation and Challenges of Networking RFID and Sensors

- From networking of human beings to networking of things
  - Wireless appliances including RFID and sensors have been successfully applied to networking of human beings
  - New value creation by networking of things
- The ubiquitous wireless networks in future will provide the real object web, while the Internet provides the information web.
- However, innovative technologies and approaches will be required to network the wireless appliances.

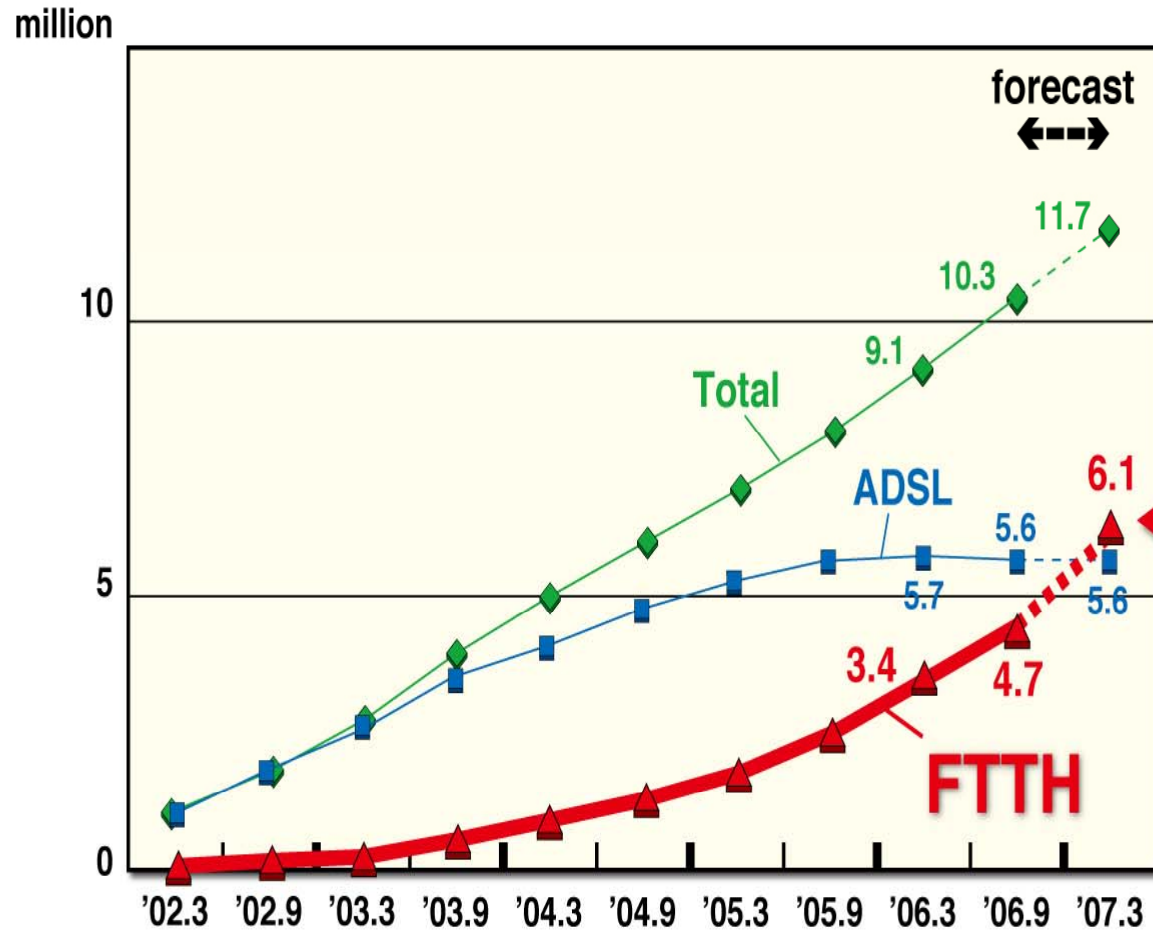
# **Trends of Networks in Japan**

# Rapidly Increasing Internet Backbone Traffic in Japan

グラフ④(参考)国内主要IX(JPIX、JPNAP、NSPIX)で交換されるトラフィックの推移



# Numbers of NTT Broadband Users

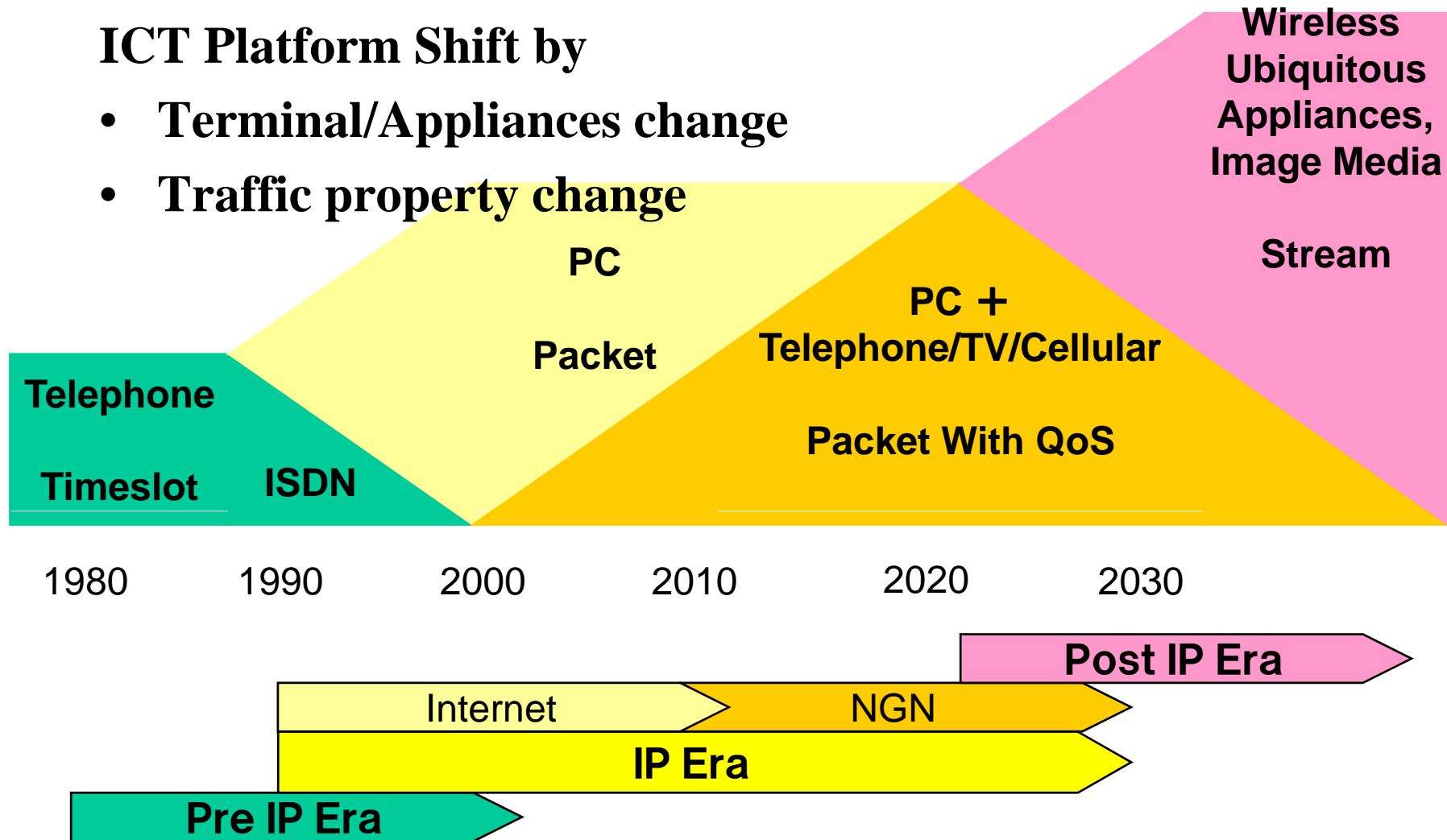


# Extraordinary Network Capacity Expansion Prepares ICT Platform Shift

# Terminals/appliances Determine ICT Platform Architectures

## ICT Platform Shift by

- Terminal/Appliances change
- Traffic property change



# Architectural Principles of the Internet

- The goal is connectivity
- The tool is the Internet Protocol
- The intelligence is end to end rather than hidden in the network

B. Carpenter, Editor: "Architectural Principles of the Internet" Internet Architecture Board, RFC1958, June 1996



# Terminals/Appliances for Ubiquitous Networks

*What are Grand Challenges of Ubiquitous  
Networks?*

# Event Search in Real World: s-room

Real-world event search & retrieval based on sensor-network environments

## Event Go!

Search for detailed information on specific “events” occurring in the real world using natural language phrases.

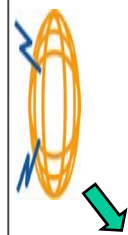
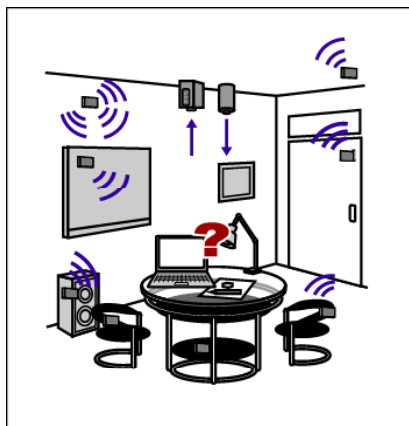
## Tag and Think

Inference of “What?” and “How?” on sensor-tagged physical objects.

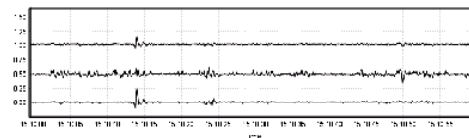
Enables us to use a huge number of physical objects & accompanying events as “contents”

## Sensor network

Always collects data produced by sensor attached to physical objects.

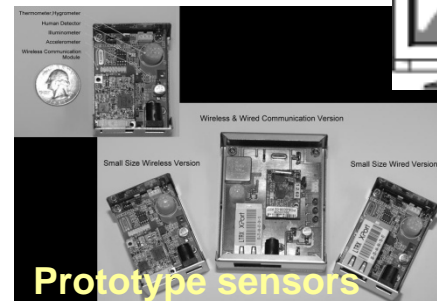


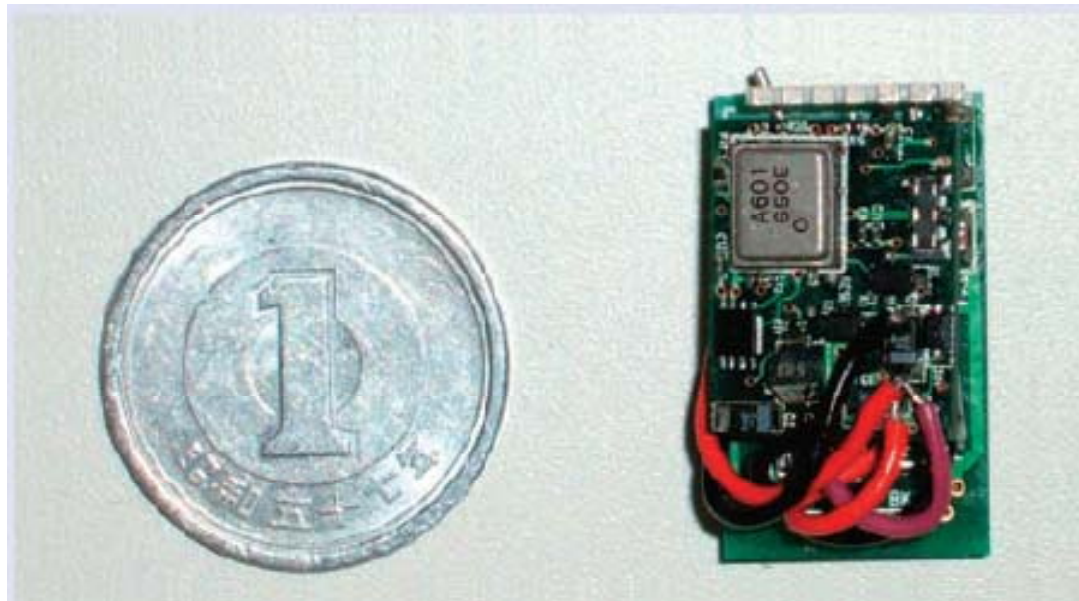
Verbalization  
(*who, drop, vase*)  
*drop(vase), walk(Taro)*



Sensor data

[Who Dropped the Vase?]





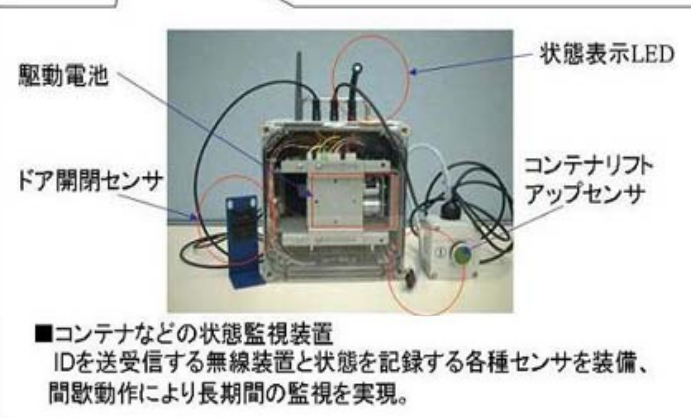
Source: <http://www.kecl.ntt.co.jp/csl/sirg/Eindex.html>

# Variety of Active RFID Tags and Readers

Cited from makers' home pages



アクティブ無線タグを用いたアプリケーションの一例



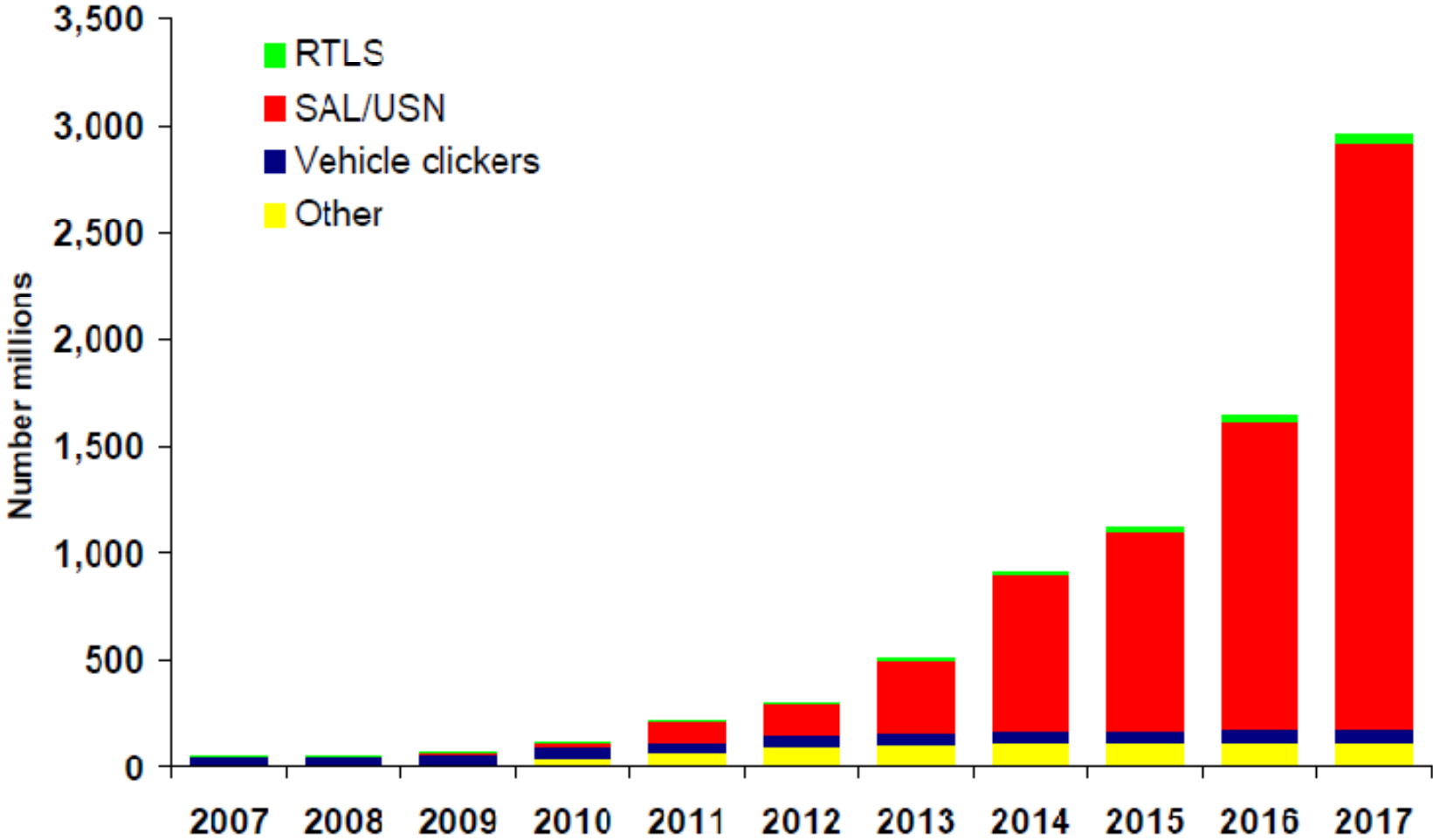
# Most Popular Active RFID: Car Clicker

- Remote keyless system with immobilizer function
- Radio Frequency
  - USA, Japan: 315MHz
  - Europe: 433.92MHz or 868MHz
- Encryption key length: 128 bits
- Life: About 5 years with a coin battery



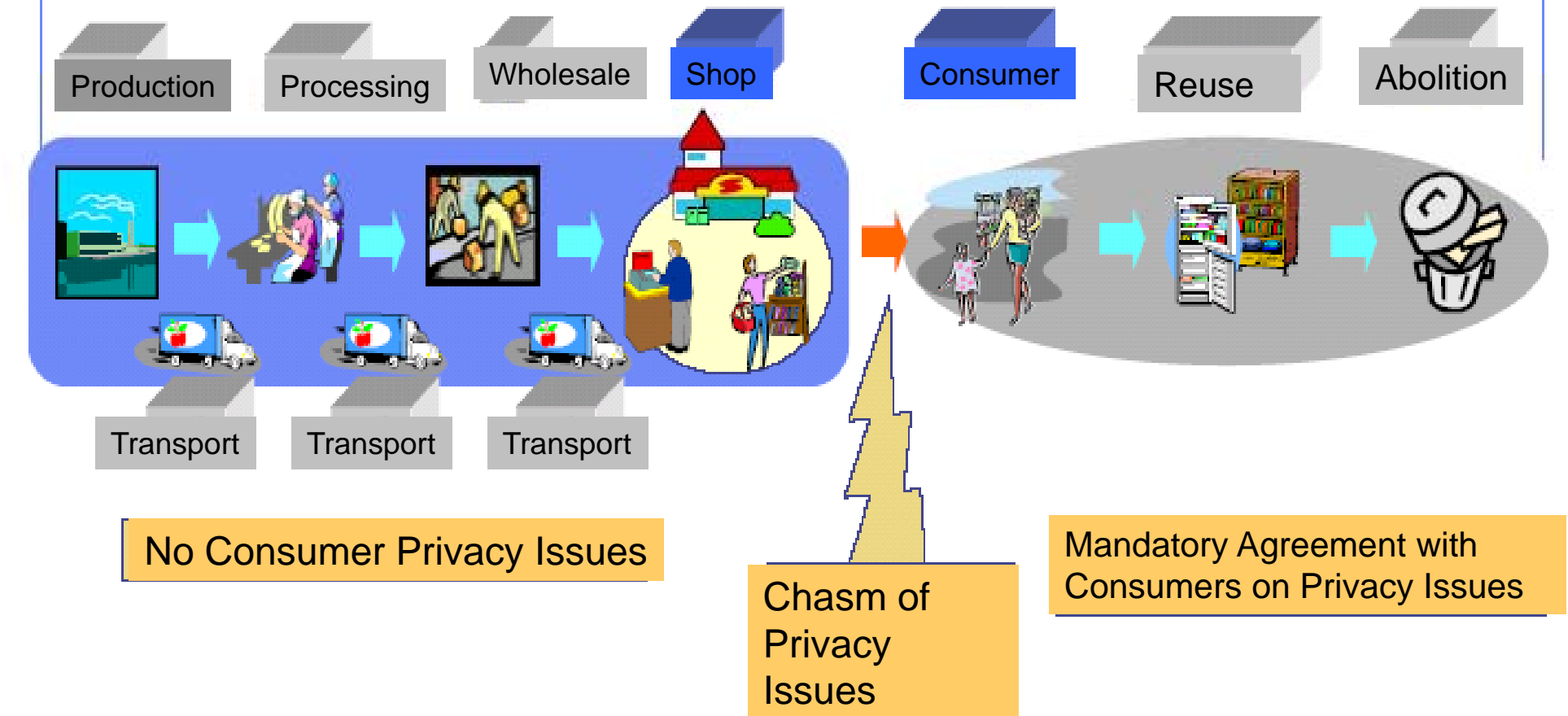
# Global Market for Active Tags in Millions 2007-2017

Figure 3 Global market for active tags in millions 2007-2017



Source IDTechEx

# Consumer Privacy Protection Mandatory for RFID Application to SCM



# Two Types of Infrastructures

- Infrastructures commercially sustainable for a specific service (area)
  - Ex) JR SUICA, Mobile phone
    - They are launched strictly according to their profitability.
  - Ex) ETC
  - Ex) Citizenship ID card
- Infrastructures supporting niche services to be commercially provided
  - Ex) Internet



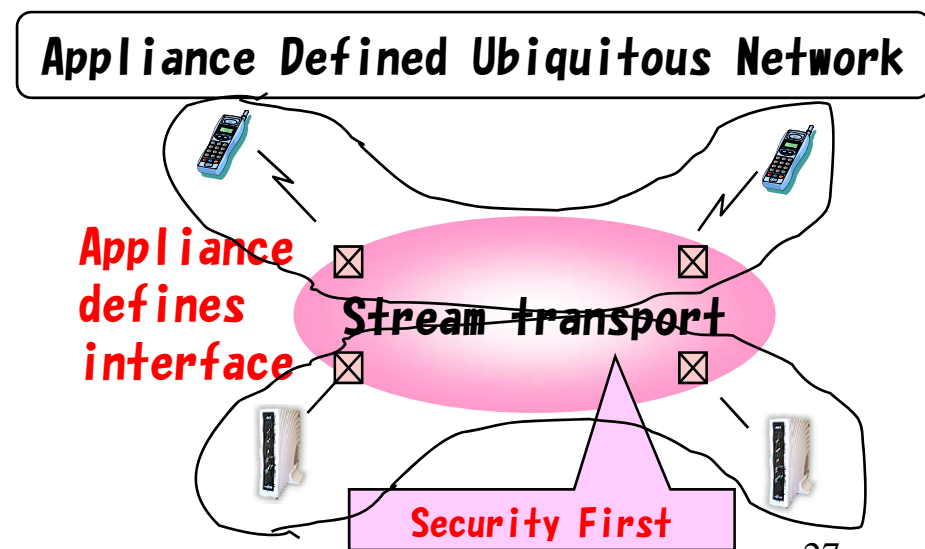
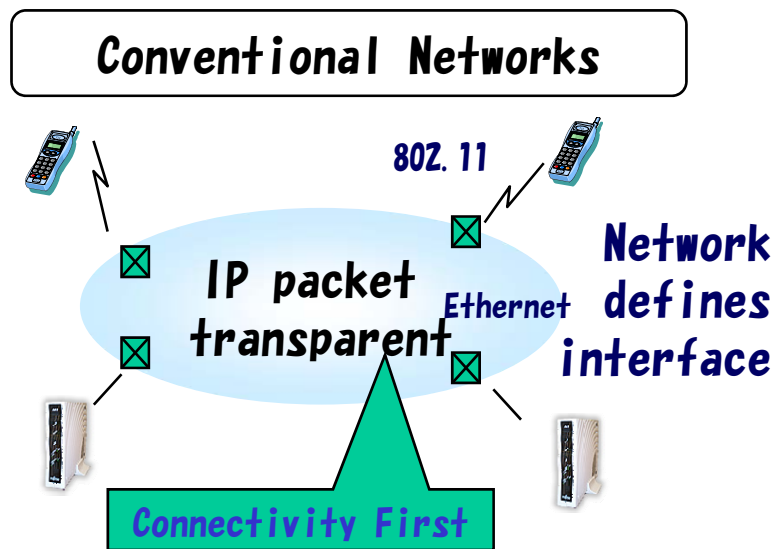
# Grand Challenges of Ubiquitous Networks

- Niche Applications / No single killer application enabling the network infrastructure
  - Almost impossible to standardize the wireless interfaces between appliances and the network.
  - Ubiquitous use of applications at low cost for construction and operation
    - Large money will not be paid for the applications while many of them will be mission critical and will demand appliance mobility
- Security and Privacy Control
  - Appliances will not be allowed to be connected to the network, where the appliances can be accessed from any hosts like the Internet unless special control mechanism installed.
- Network Infrastructure Creation and Evolution
  - Efficient migration from the Internet / Efficient use of the existing infrastructures
  - Accommodate functionally improved appliances and technologies in the future

# ADUN: Appliance Defined Ubiquitous Network

# ADUN: Appliance Defined Ubiquitous Network

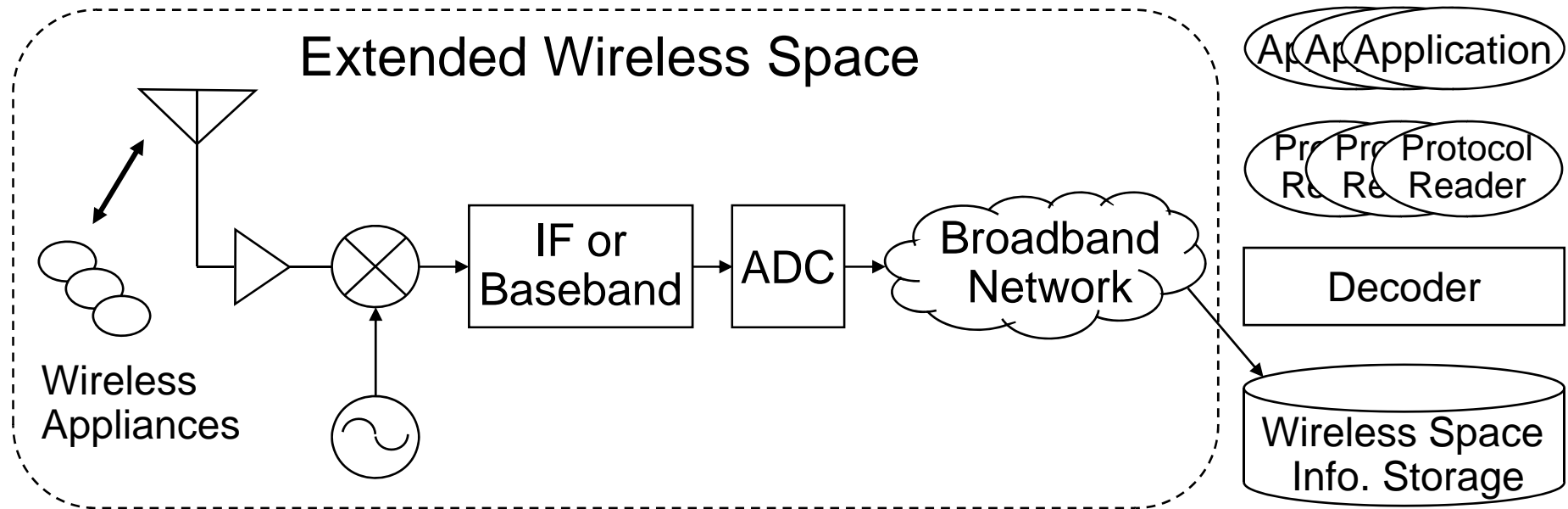
- Networks speak any protocols of wireless appliances
  - Conventional networks define the protocols for appliances to speak
- Continuous radio data **streams** are transported over networks.
- **Security first**
  - Networks comprise personal private networks
  - Data from appliances are collected and processed under the appliance owner's control
  - Signals from the wireless spaces and appliances of different owners are inter-networked by **administrators trusted by the owners.**



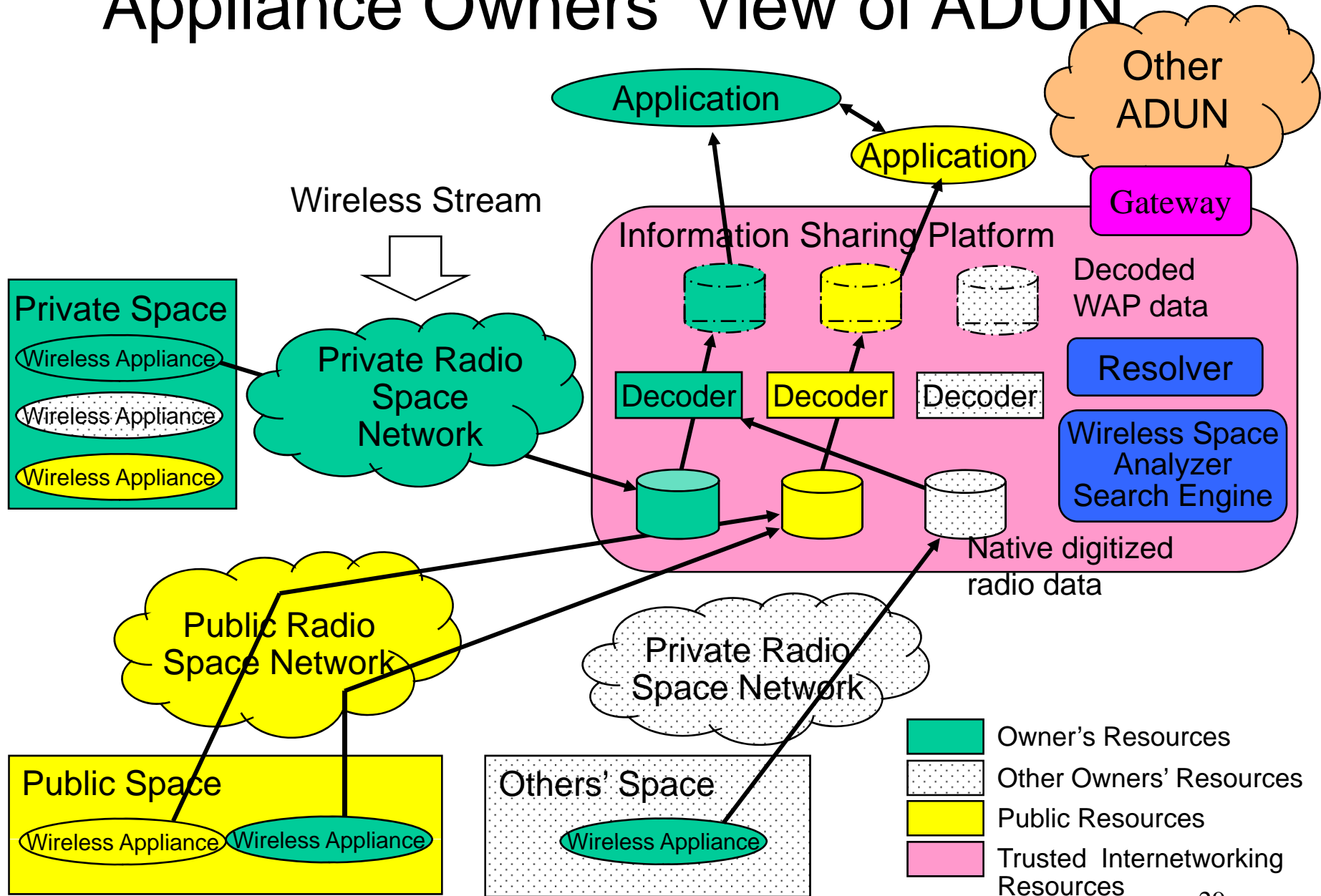
# Radio space extension with DROB and SDR

*DROB: Digital Radio On Broadband Networks*

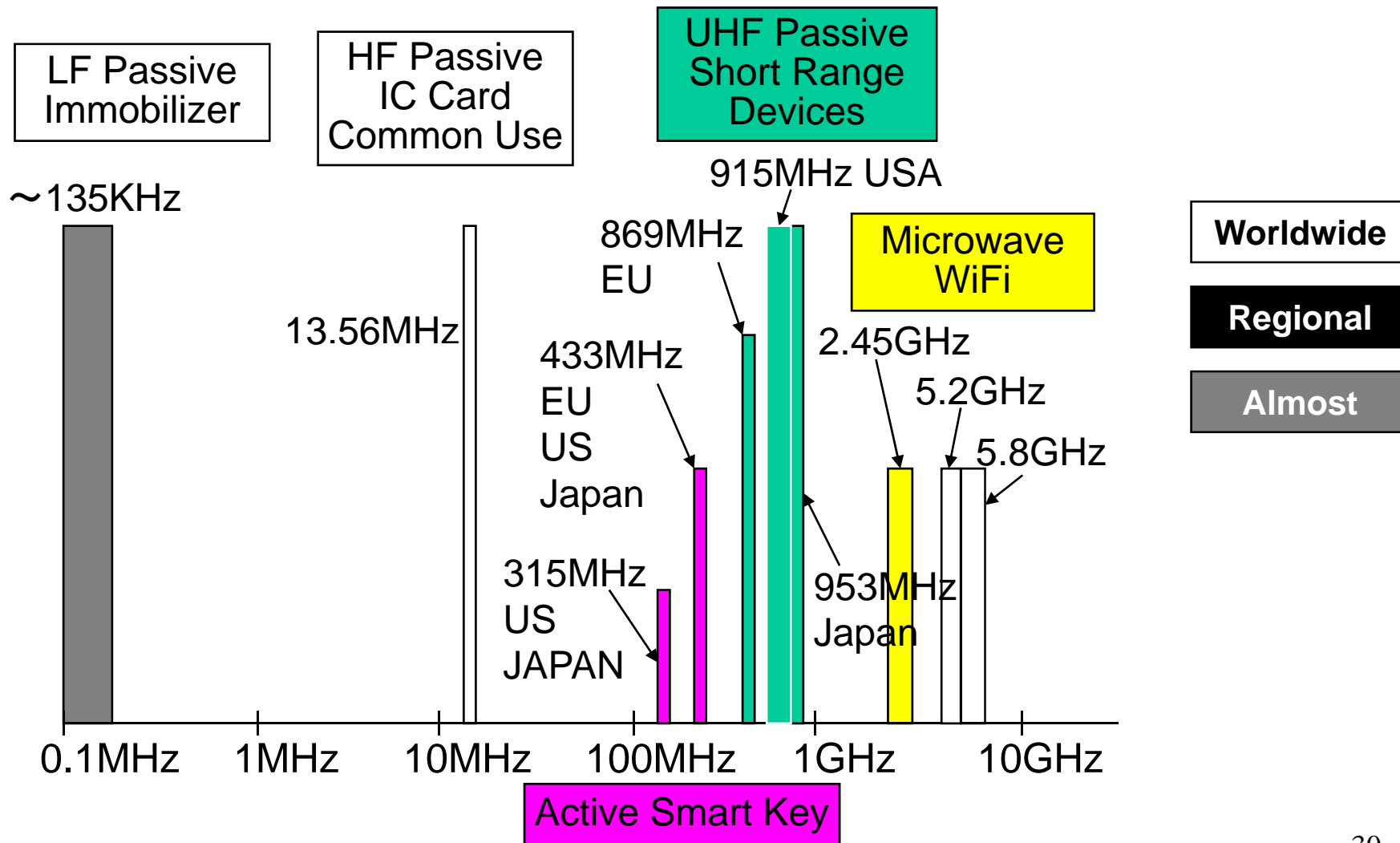
*SDR: Software Defined Radio*



# Appliance Owners' View of ADUN

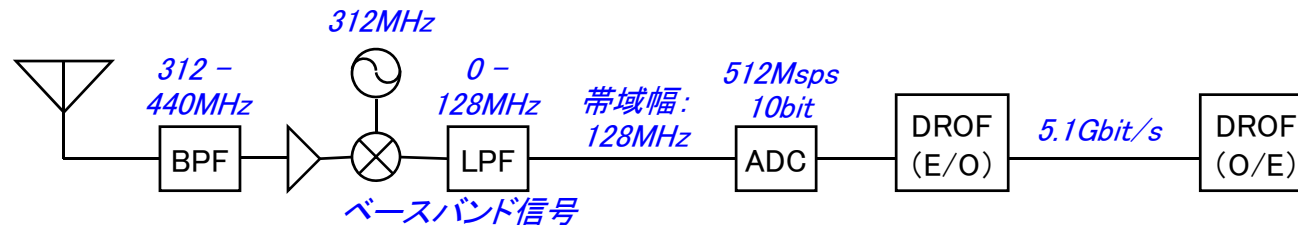


# Three Types of Wireless Appliances and Frequency Allocation

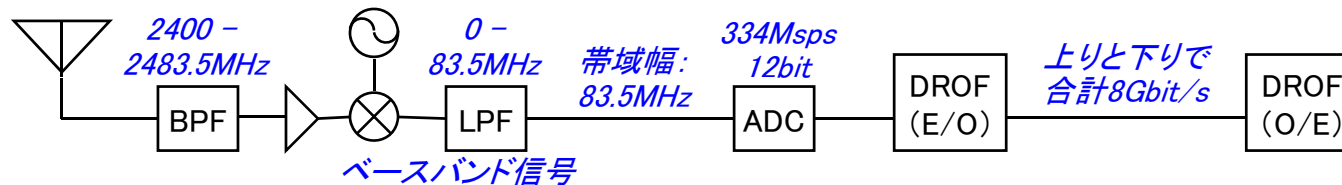


# Overhead of Wireless Space Networks

Band of 128MHz from 312 to 440MHz is digitized to **5.1Gbps**.



Band of 83.5MHz from 2.4 to 24.835MHz is digitized to **8Gbps**.



# Comparison of the Internet and ADUN in Architectural Principles

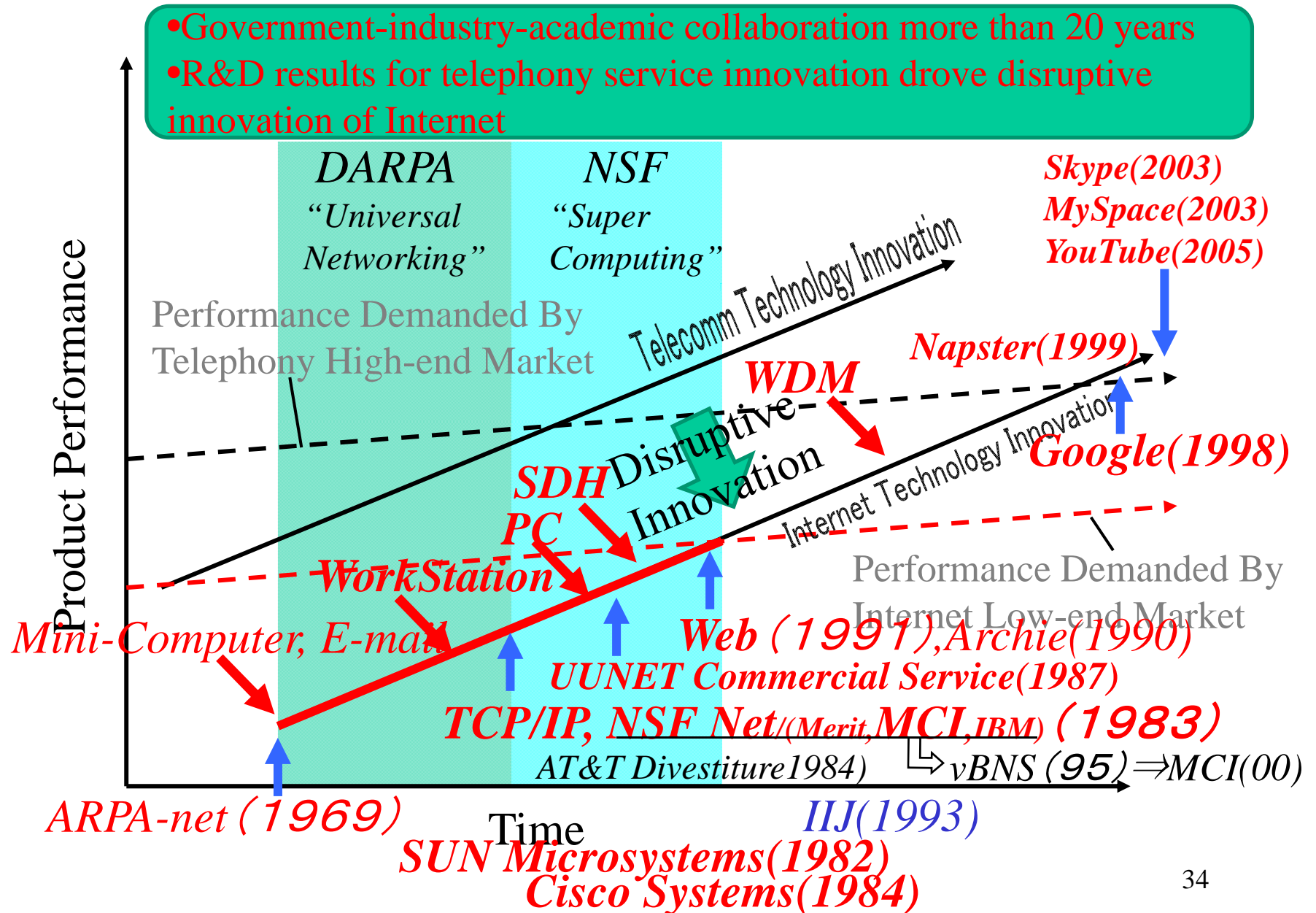
- The goal is connectivity
  - ➡ **Closed networking of appliances on individual user basis (Security First)**
- The tool is the Internet Protocol
  - ➡ **Protocol to virtually extend radio spaces (Packet => Stream)**
- The intelligence is end to end rather than hidden in the network
  - ➡ **The intelligence is entrusted to the agents in the network**



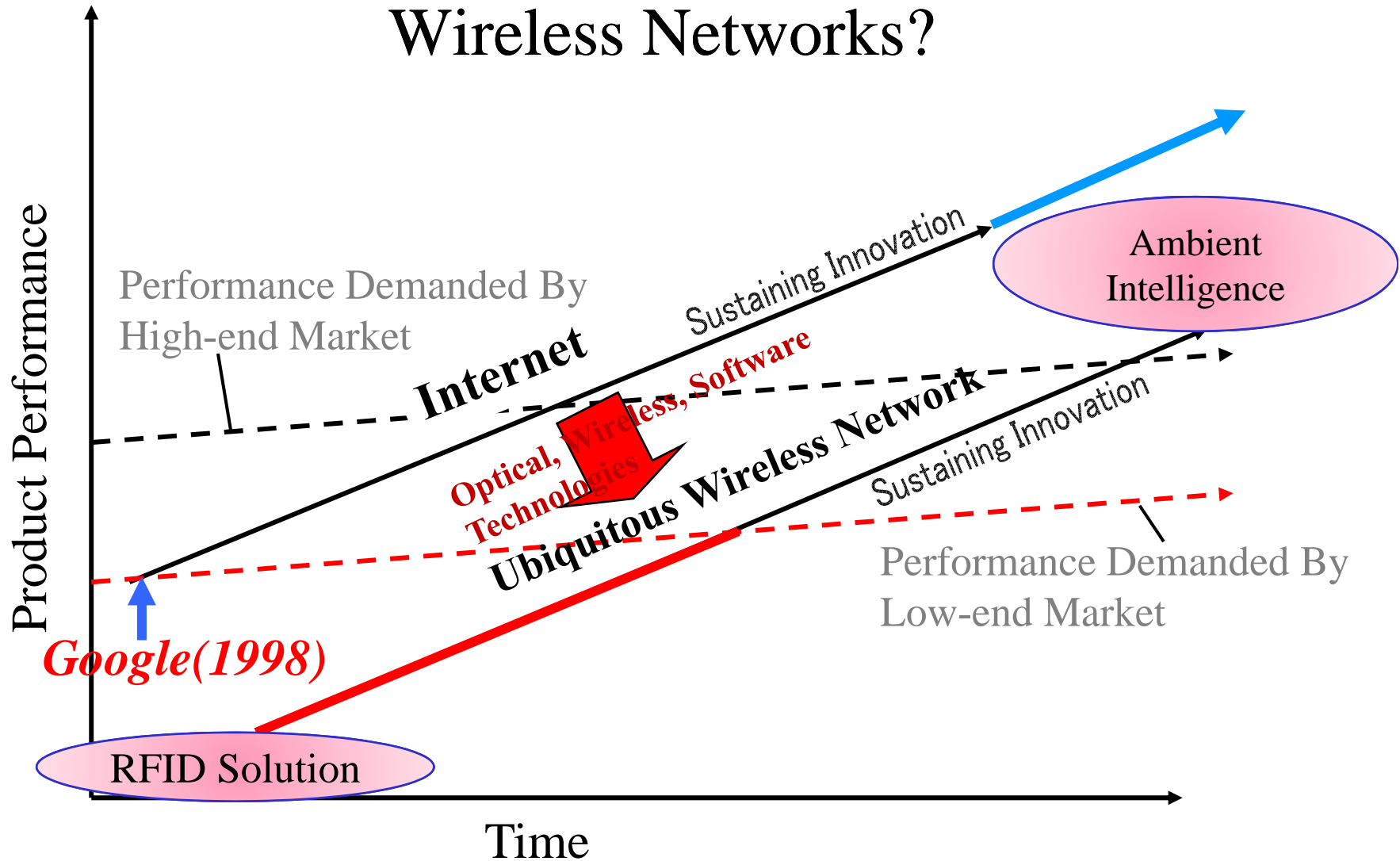
# Approach to ADUN

- Based on the history of the Internet

# The Internet Evolution Through Disruptive Innovation



# Another Disruptive Innovation of Ubiquitous Wireless Networks?



# Industry Creation Platform as R&D Target

- Architectural principles for networks
- Technology seeds
- Daily use applications useful for network evolution and deployment
- Communities of researchers and engineers
  - Use the applications and improve the network and application technologies

# Approaches Towards Ubiquitous Networks

