

Ultra 3G with Multi-System and Cooperative Radio

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Outline

1. Introduction of KDDI and KDDI R&D Labs
2. "Ultra-3G " Plan and Recent R&D Topics
3. Cognitive and Cooperative Radio

1. KDDI Corp. and KDDI R&D Labs, Inc.

Features of KDDI Corp.

- 2nd largest communication operator in Japan
- Provides both wired and wireless services

- Internet service using FTTH and ADSL
- Leased-line service including IP-VPN and Ether-VPN services

- Cellular service: "au by KDDI"
 - 3G users: approaching 30 millions
- Satellite service
- FWA service

FMBC (Fixed Mobile Broadcasting Convergence) is the keyword

KDDI R&D Labs. is

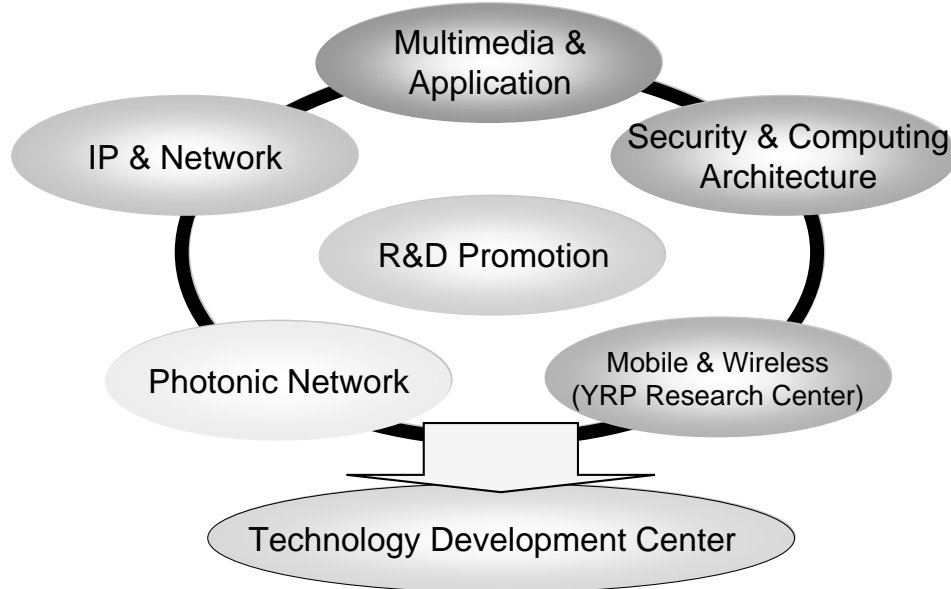
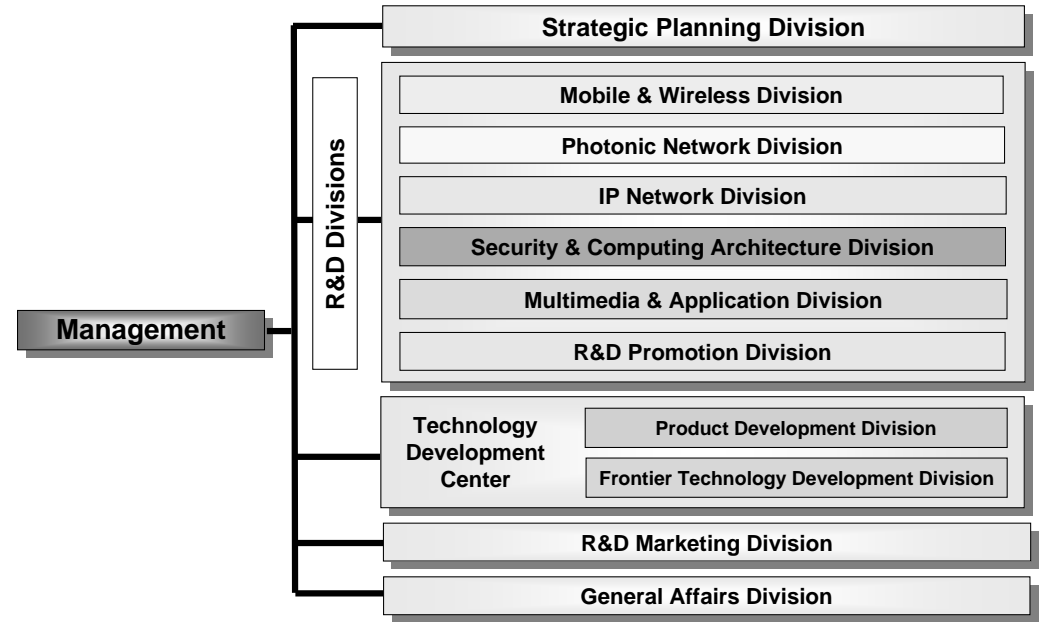
- one of affiliate companies of KDDI (Shareholders incl. Kyocera and TOYOTA)
- focusing on researching and developing next-generation technologies

- Company Name: KDDI R&D Laboratories Inc.
- President and CEO: Shigeyuki AKIBA
- Total Employees: 270 (April 1, 2008)
- Capital: 2.28 billion Yen
- Shareholders: KDDI, Kyocera, and Toyota
- Office: Headquarter
Fujimino, Saitama



Technology Development Center
Chiyoda-ku, Iidabashi, Tokyo

YRP Research Center
Yokosuka, Kanagawa

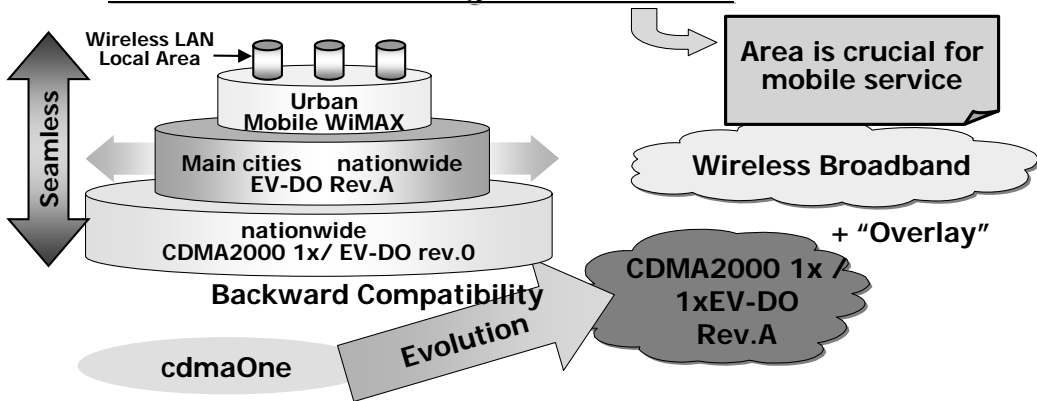


2. "Ultra-3G" Plan and Recent R&D Topics

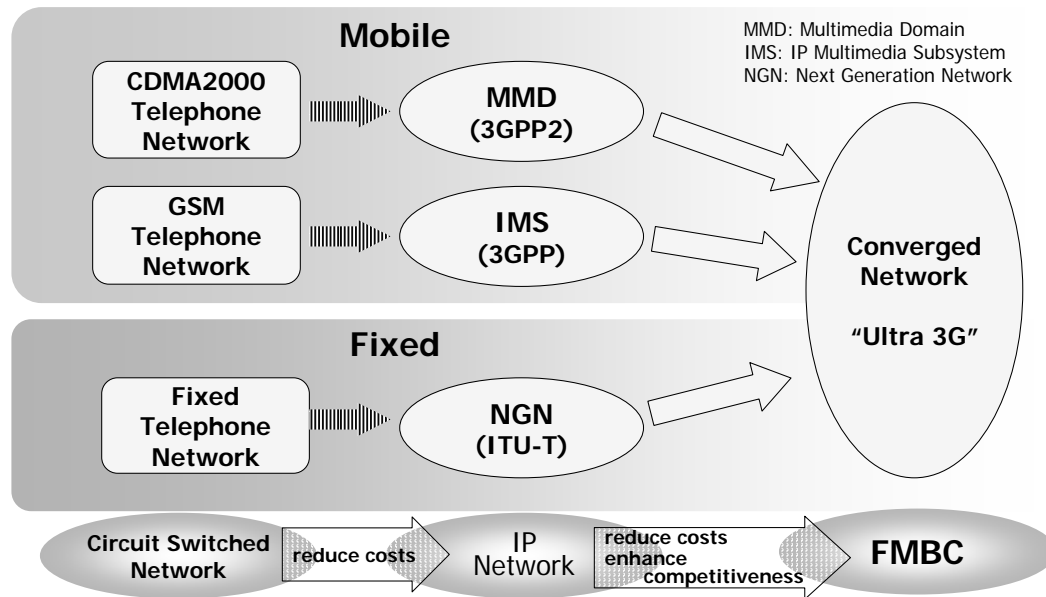
Wireless Access Evolution



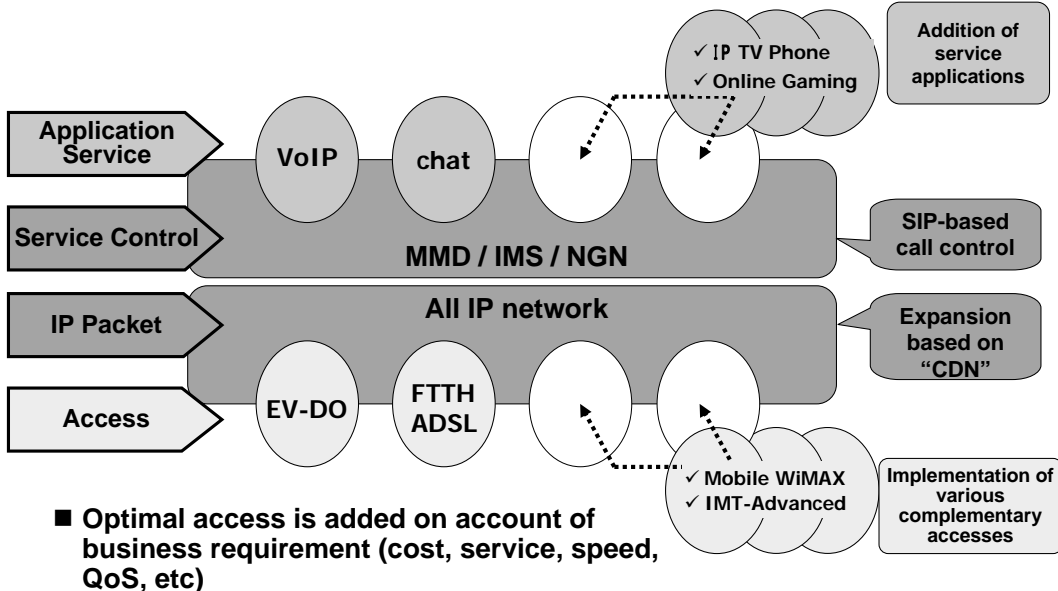
- ✓ "IMT-Advanced" is composed of various wireless accesses
 - Overall competitive network with complimentary access methods depending on cost and throughput
- ✓ KDDI adopts "Overlay Approach" in WBB development
 - Provision of dense coverage area nationwide



Migration of Core Network to All-IP



Service Development in "Ultra 3G"

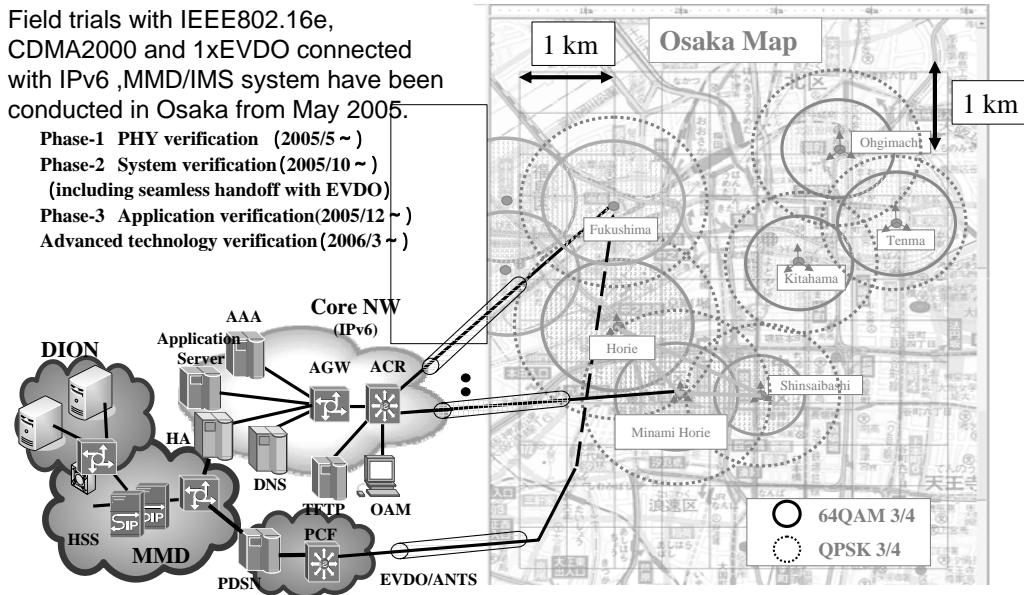


Field Trials as a Showcase of "Ultra 3G"



Field trials with IEEE802.16e, CDMA2000 and 1xEVDO connected with IPv6, MMD/IMS system have been conducted in Osaka from May 2005.

- Phase-1 PHY verification (2005/5 ~)
- Phase-2 System verification (2005/10 ~) (including seamless handoff with EVDO)
- Phase-3 Application verification (2005/12 ~)
- Advanced technology verification (2006/3 ~)



Video Streaming Demonstration

Concurrent multiple streams
incl. live up-streams



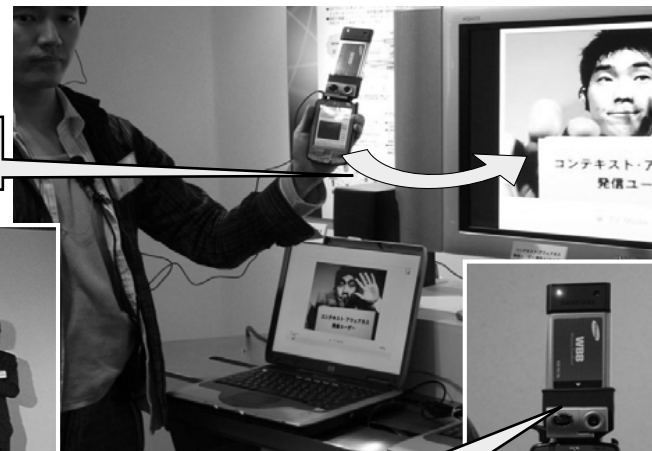
at exhibition site



on a chartered bus
going around urban area

Service Mobility Demonstration: Mobile <-> Fix

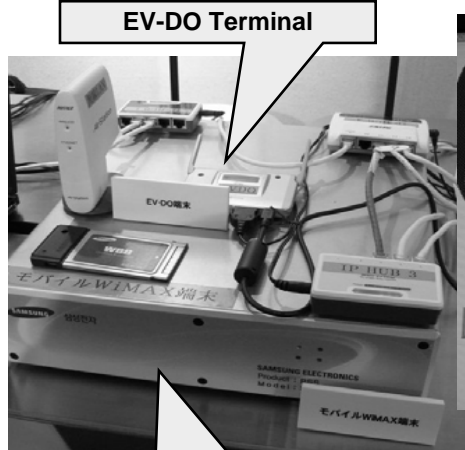
Media switching from
Mobile to Fixed



PDA handset
with Mobile WiMAX card

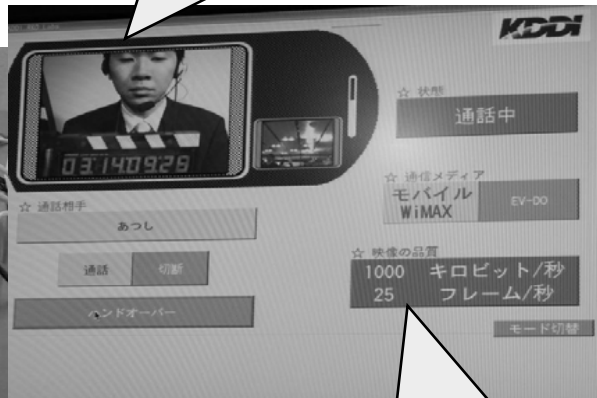
Seamless Handover : EV-DO <-> Mobile WiMAX

IP video telephony



EV-DO Terminal

Mobile WiMAX Terminal



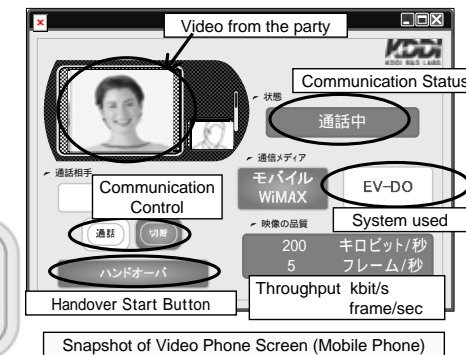
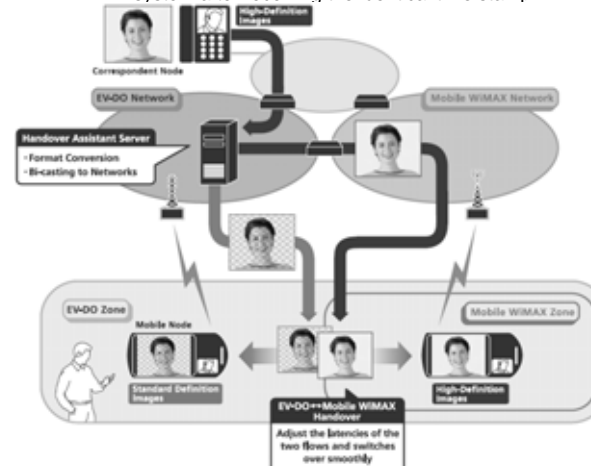
Optimum frame rate
under each access system

Smooth Handover between Heterogeneous Mobile Networks

Overview

Smooth Handover between heterogeneous mobile networks, like mobile WiMAX and EV-DO

- > A handover assistant server determines the rate of each wireless systems, then bi-casts images to them according to the corresponding service quality.
- > A mobile phone adjusts the difference of latencies of 2 bi-cast flows, and switches over the system after receiving the identical time stamp.



Mobile Radio Transmission Scheme for IMT-Advanced

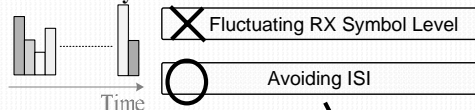


Overview

Mobile radio transmission scheme for efficiently higher bit rate communications

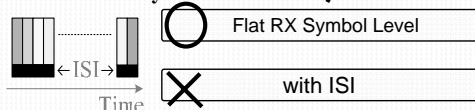
- New multi-carrier transmission scheme (R-OFDM) using new spreading codes (rotational codes), having both merits of conventional, typical schemes (OFDM and MC-CDM)
- Demodulation without de-spreading, inner and outer Turbo decoders with demodulator (Twin Turbo Decoder)

OFDM RX Symbol



Can both merits be in single scheme ?

MC-CDM RX Symbol

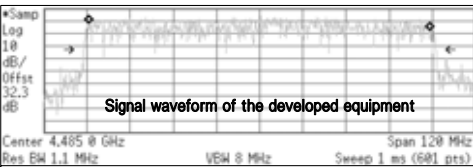


* ISI: Inter Symbol Interference

Efficient Mobile Radio Transmission for Higher Data Rate



Demonstration on the test bed



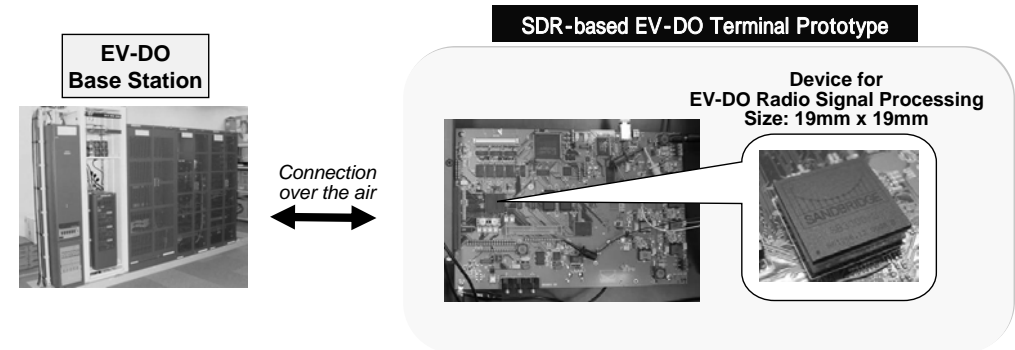
Mobile Terminal Based on SDR



Overview

Developed a mobile terminal based on SDR (Software Defined Radio), which enables to change radio functions without replacing a hardware and also enables bug fix of radio functions after terminals are released to the market.

- Realized software radio signal processing for CDMA2000 1xEV-DO up to 2.4 Mbit/s on a low power consumption device (approx. 700mW and reducible to 300mW with an improved device).
- Mobile WiMAX software also available for a dual-mode terminal.



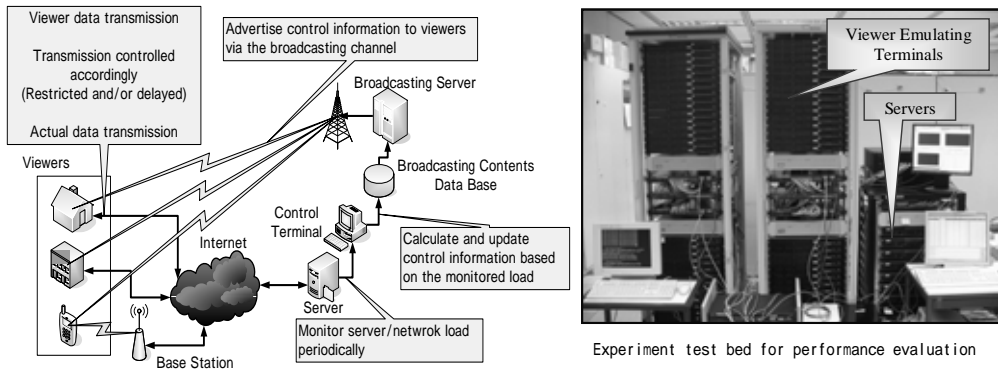
Traffic Congestion Avoidance for Communication-Broadcasting Integrated Services



Overview

Technology to avoid traffic congestion caused by communication-broadcasting integrated services.

- Induced traffic tends to be intensive, bursty and massive in communication-broadcasting integrated services
- Reliable communication services can be provided by controlling user traffic.
- The control information is advertised to users via the broadcasting channel.



Service Migration & W-DLNA System



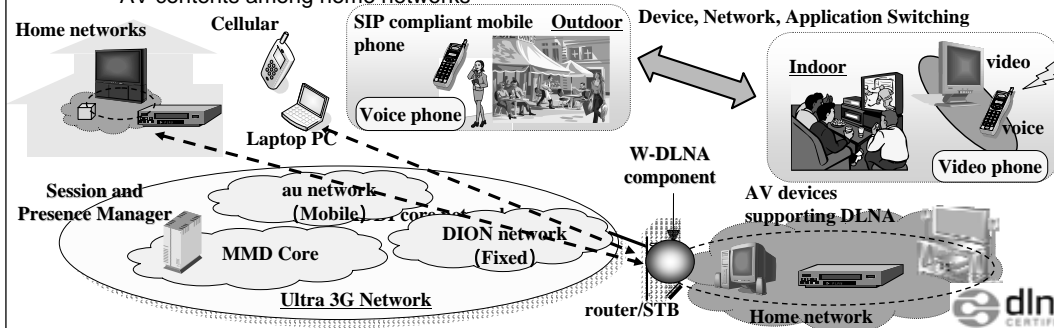
Overview

Service Migration System provides optimum service on FMBC environment according to user's resource and preference.

- Terminals, applications, and networks can be flexibly switched by a unified fashion based on SIP without terminating an ongoing session.

W-DLNA (Wide area – Digital Living Network Alliance) system allows user to access own AV contents stored in a home network from everywhere.

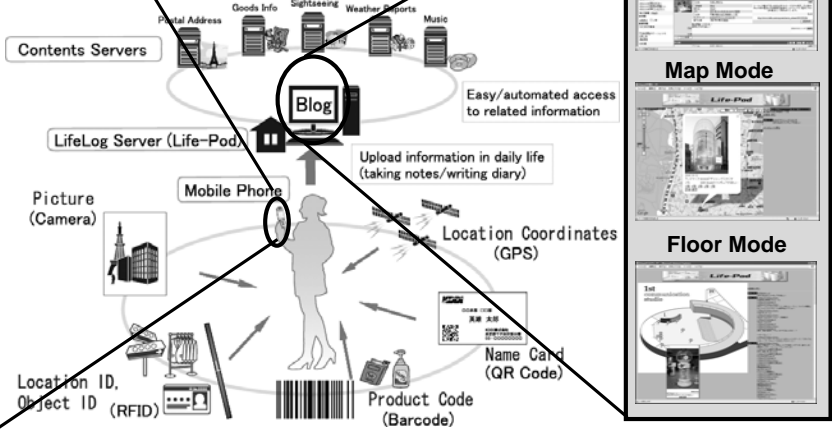
- A component in a home network acts as a proxy and communicates with DLNA devices in the home behalf of a user terminal (e.g. cellular, PDA, PC) on an external network.
- User can enjoy AV contents stored in the DLNA devices from outside world or share the AV contents among home networks



Mobile phone based "Life log"

Featured Technologies

- 1) Semantic web based data management (RDF/RDFS, OWL, ontology)
- 2) Mobile phone based "Life Log" (Various IDs in real space are automatically bind with data on networked servers)
- 3) Mush-up GUI
- 4) User profile extraction / inference

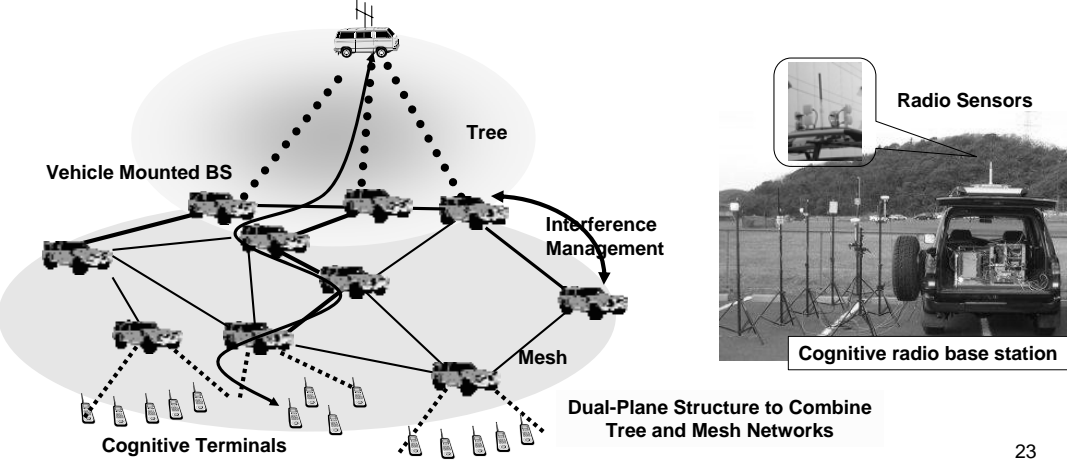


3. Cognitive and Cooperative Radio

Cognitive Wireless Network (2005-2007, supported by MIC)

Objective / Background

To establish the novel methods to expand the radio frequency resources in congested or contingency cases. A wireless network shall be deployable in a flexible and quick manner. (e.g. in case of natural disaster)



"Cognitive" Radio

Challenges

- How cognitive (intelligence) ?
 - Radio environment recognition algorithm, plus possibility of prediction
- How reactive (link-level, real-time management)?
 - Radio Interface Management (e.g. spectrum (media/system), space (beam), time (switching))
- How cooperative (network-level management)?
 - Mesh Network Management (e.g. topology, route, traffic flow)

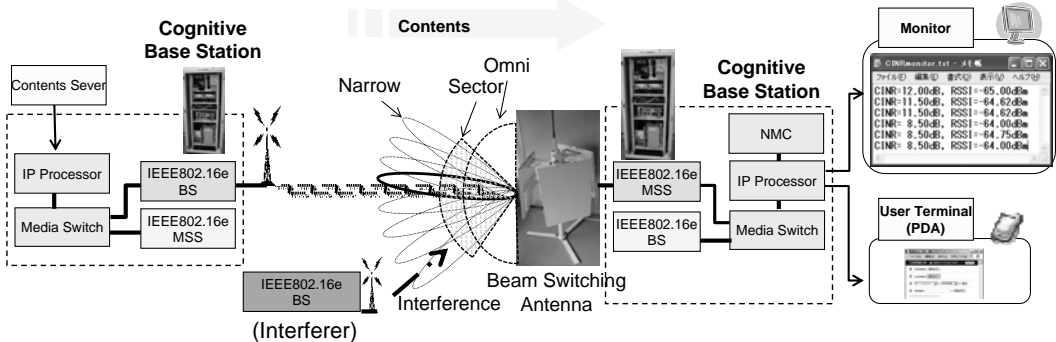
Beam Switching for Interference Management (1/2)



Beam Switching for BS-to-BS Network (flexible and quick deployment)

Approach: Adaptive beam switching using various types of beams (1 omni, 1 sector and 8 narrow beams per antenna)

Prototype: Applying mobile WIMAX system, the field experiment demonstrates that the proposed system improves about 8 dB in terms of CINR.



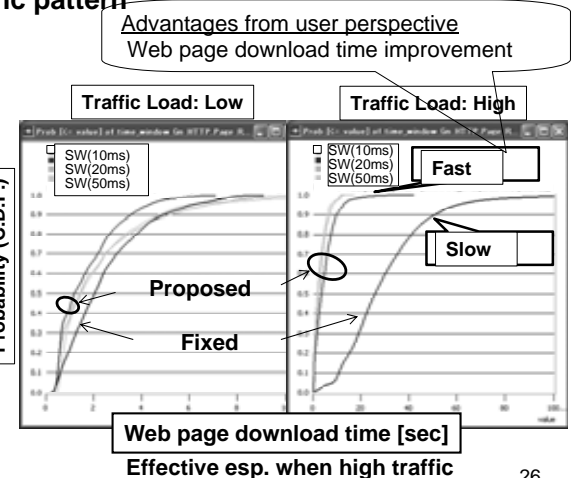
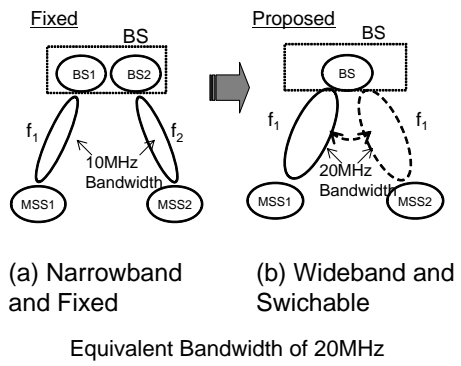
Beam Switching for Interference Management (2/2)



Beam Switching for Access Links

Simulation Results:

- (1) Quicker application-level response time
- (2) Effective for asymmetric traffic pattern

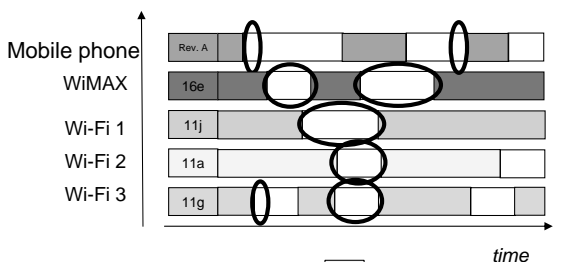


Cognitive Radio using Multi-Transmission Links



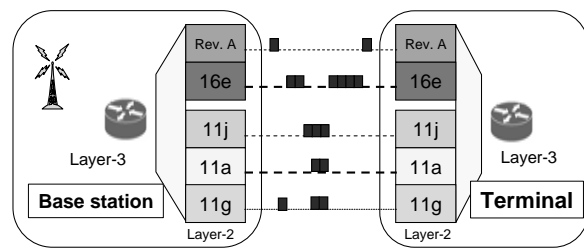
Objective / Background

The proposed method includes a bundle of multiple radio media, as a single virtual link, and makes maximum use of "white space" on a second-by-second basis.



Target / Outputs

To investigate the radio environment recognition algorithm by the field experiment campaigns using the prototype radio stations.



Media Selection/Combining Algorithm

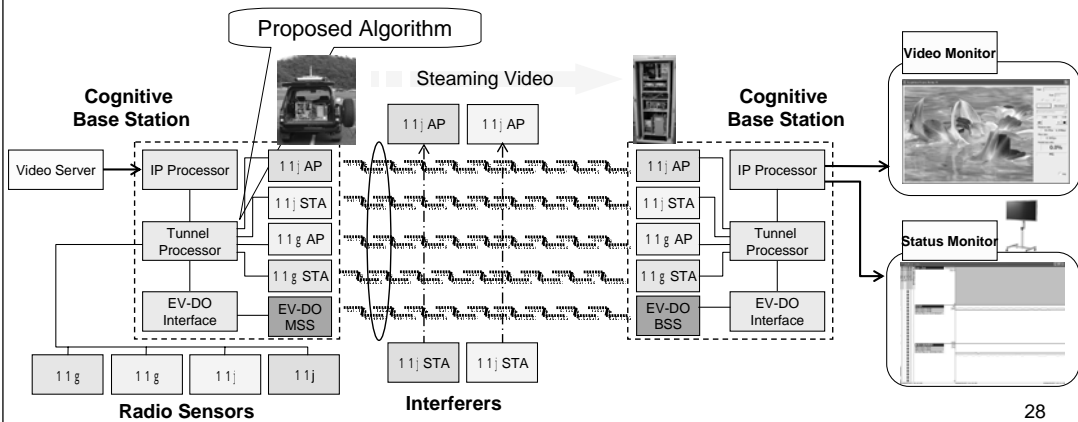


Multi-Transmission Link (Virtual Link)

Approach: Tunnel processor handles virtual MAC layer (Layer 2.5)

Radio availability is recognized by introducing a new measure.

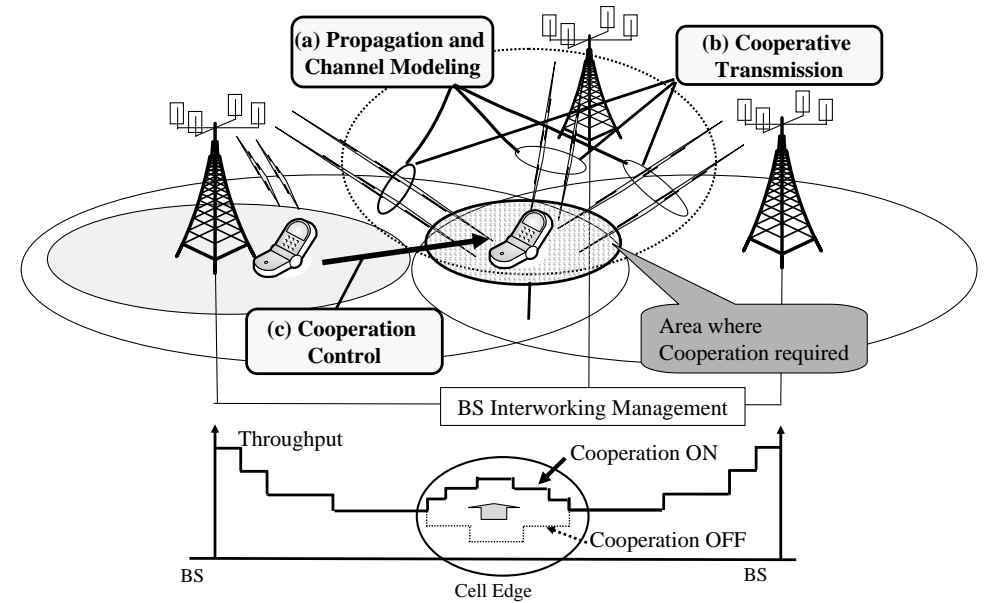
Prototype: Proposed algorithm demonstrate effective spectrum usage achieving high-quality streaming video transmission even with interferers.



Cost-Effective Deployment

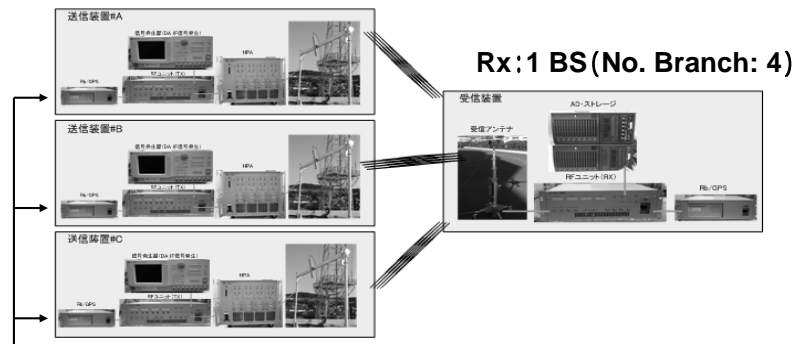
- Area Deployment for MIMO would be the Key, in terms of bps/¥, for Next Generation Mobile Communication Services
- We should consider two cases:
 - ✓ Outdoor
 - ✓ Indoor (incl. underground and inside vehicles)
- Heterogeneous Deployment
 - ✓ Interference Management (Macro/Micro/Pico/Femto)
 - ✓ Multi-Hop (via Relay)

Multi-Site MIMO (2007-2009, supported by MIC)



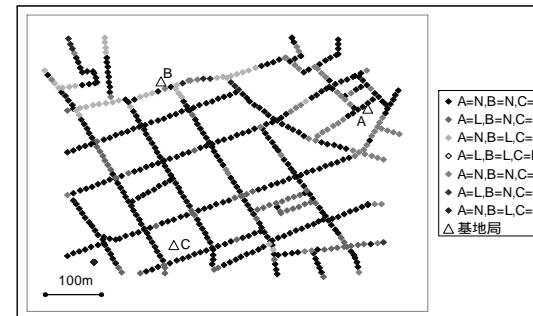
Multi-Site Propagation Measurement

Tx: 3 BS's (Center Freq.: 4.65GHz, Bandwidth: 20MHz, No. Branch: 4)

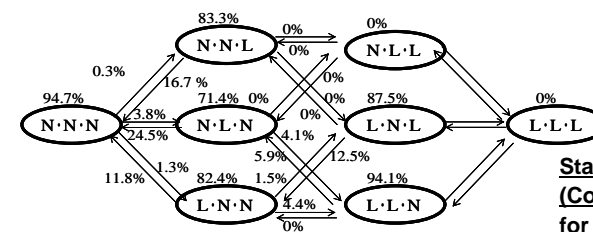


Synch. with GPS

Multi-Site Propagation Modeling



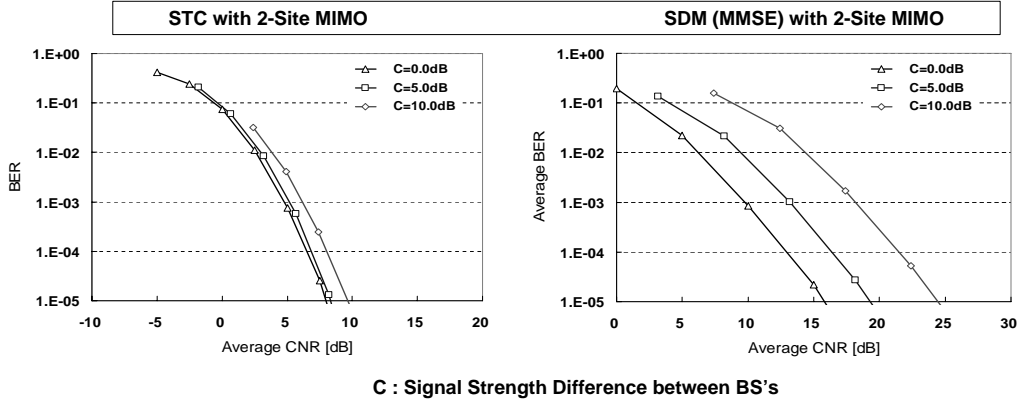
LOS or NLOS evaluation (Both Ray-Tracing and Field Validation)



State Transition Diagram (Combination of L/N for 3 BS's)

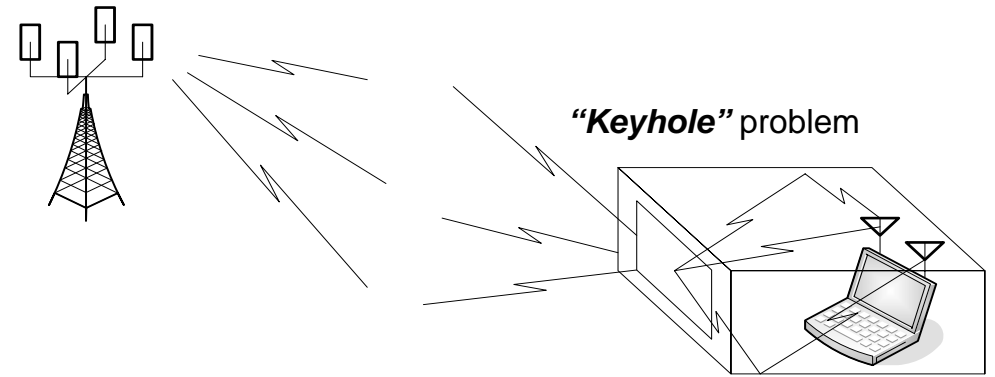
L/LOS: Line-Of-Sight, N/NLOS: Non-Line-Of-Sight

Multi-Site MIMO Transmission Scheme



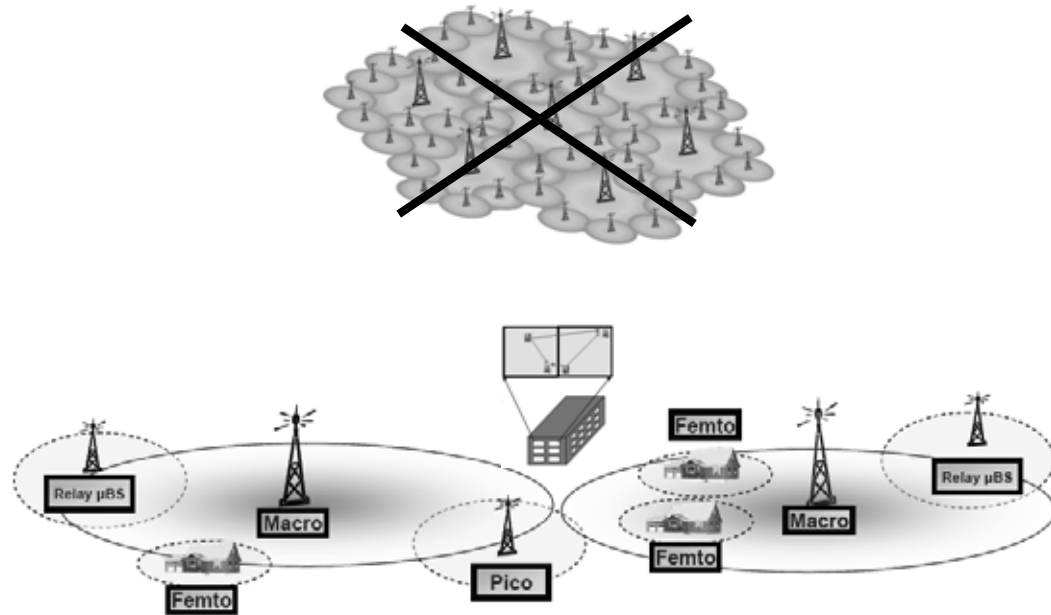
STC: Space-Time Coding
 SDM: Space Division Multiplex
 MMSE: Minimum Mean Square Estimation

Indoor: Penetration from Window(s)



- ◆ Direction and Size of Window(s)
- ◆ Repeater/Relay work?

Heterogeneous Deployment



Thank you